State of Idaho
Department of Administration
Division of Public Works

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ADDENDUM NO. 1

December 5, 2022

TO: Design-Build Teams

FROM: Pat Donaldson, DPW Administrator

SUBJECT: DPW PROJECT NO. 23881
State of Idaho Deferred Maintenance Program
Idaho State University; Pocatello, Idaho

RFQ – ADDENDUM NUMBER ONE

The following addendum applies to the above referenced project and is included as part of the Request for Qualifications (RFQ). Acknowledge this addendum within your cover letter of your submittal. Please make certain to include a specific contact name and email address for future correspondence with the cover letter.

Clarifications:
1) The project titled "045 Reed Gym/HVAC phase two" has been dropped from the project list:
    a. Modify the last part of the first sentence of the CONTRACTUAL REQUIREMENTS section to read "…stipulated sum of $24,248,476."
    b. Above-referenced project removed from Appendix D – Agency Project List
2) Attached to this addendum is the Pre-Proposal Meeting Sign-In Sheet, Pre-Proposal Meeting Presentation Slides, updated version of Appendix D – Agency Project List, and copies of available engineering studies and reports.

Attachments:
1) Pre-Proposal Meeting Sign-In Sheet
2) Pre-Proposal Meeting Presentation Slides
3) Appendix D – Agency Project List
4) Master Plan – Central Heating Plant, performed by RMH Group, dated 9/13/21
5) ISU Pool Investigation, performed by Martin/Martin Wyoming, Inc., dated 8/23/21
6) Reed Gym and Student Recreation Center Swimming Pool Leak Assessment Study, performed by Water Design, Inc., dated 9/23/21

END OF ADDENDUM NUMBER ONE

Idaho Department of Administration DIVISION OF PUBLIC WORKS

Idaho State University Design Build Services
Pre-Proposal Sign-in Sheet

Project: Idaho DPW – Idaho State University DB Services

Meeting: Pre-Proposal Meeting

Date: November 30, 2022

Time: 3:00 P.M MST

Name	Company	Email
Travis Casch	Jacobs	travis.casch@jacobs.com
Barry Miller	DPW	barry.miller@adm.idaho.gov
David Keil	ESI	davidkeil@esiconstruction.com
Pat Donaldson	DPW	pat.donaldson@adm.idaho.gov
Dan Maffuccio	Jacobs	dan.maffuccio@jacobs.com

Jacobs

Idaho State University Design Build Services
Pre-Proposal Sign-in Sheet

Project: Idaho DPW – Idaho State University DB Services

Meeting: Pre-Proposal Meeting

Date: November 30, 2022

Time: 3:00 P.M MST

Name	Company	Email
Tim Tolman	McKinstry	timt@mckinstry.com
Matt Guerin	RMH Group	mguerin@rmhgroup.com
Katie Gwinn	ESI	katiegwinn@esiconstruction.com
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Steve Hagler	Idaho State University	
Chris Baker	Idaho State University	

IDAHO

Department of Administration

DIVISION OF PUBLIC WORKS

DEFERRED MAINTENANCE PROGRAM

Design Build Services RFQ

Jacobs

Program Overview

- Over $900 million deferred maintenance backlog
- First $244 million appropriated—budget allocations for each participating Agency, based on square footage of assets and Agency priorities
- First 3 RFQ's released for work at 3 major universities
- More RFQ's will follow for balance of work
- Robust program—Funding allocations and scope of work can change

Design Build Services

- Stipulated sum shown in the RFQ is the approved budget for each Agency for the project list shown in Appendix D.
- Progressive DB approach to deliver the maximum number of projects possible based on Agency priority list
- Maximize Project Value--Transparent, interactive approach with the Agency and the Owner to balance costs with Agency priorities project value
- Will adjust base Design Build Contract to meet these reqts.

Design Builder Qualifications

- Proposer's Size/Depth and Experience necessary to deliver work as described
- Experience and knowledge of local market (subcontractor labor, materials and equipment)
- Design Build Experience
- Campus and Higher Education
- Fill out Appendix A

Team Member Qualifications

- List organizational approach including key members of the organization expected to accomplish the work.

- Describe qualifications and roles of each

Technical Approach

- Level of design development needed to obtain Agency satisfaction and pertinent approvals and permits
- Address solutions to current market conditions
  (escalation and supply chain)
- Address Commissioning requirements of system components/improvements with existing systems

Project Management Approach

- Quality Management-Address Stakeholder needs, Life cycle costs, Agency O&M requirements
- Schedule and Logistics Management-Address coordination of Agency operations and seasonal challenges, procurement lead times and workflow challenges
- Cost Management-approach to optimizing value by delivering the maximum amount of projects using an Integrated Project Delivery approach

Past Performance and Format

- Past Performance-Submit Appendix B per instructions

- Format- Follow Proposal Outline
  - Provide clear and concise responses

Questions?

Appendix D

Agency Project List

PROJECT LIST

Agency	City	Scope of Work	Priority	Estimate	Previous Studies and/or Preliminary Design Work
Idaho State	Pocatello	020 Heat Plant/Major improvements needed to prolong life of plant	1	$ 15,607,500	Central Heating Master Plan was completed by RMH Group (CO) about a year ago. .
Idaho State	Pocatello	PK14-G01/General Parking Lot G-01 safety hazards & repairs	2	$ 2,622,000	Prelim plans completed by Keller
Idaho State	Pocatello	011 Fine Arts/Replace chiller	3	$ 470,400	
Idaho State	Pocatello	045 Reed Gym/Swimming Pool Repair and Replacement of aged equipment and systems	4	$ 1,177,500	Feasibility Study w/options performed by Water Design Inc. 9/23/21
~~Idaho State~~	~~Pocatello~~	~~045 Reed Gym/HVAC phase two~~	~~5~~	~~$ 721,524~~	
Idaho State	Pocatello	003 Physical Science/Upgrade HVAC Phoenix Controls	6	$ 2,147,625	Preliminary study completed by SEED Engineering
Idaho State	Pocatello	099 Campus/Pocatello - roads and parking Bartz Way mill & overlay	7	$ 1,995,000	Part of Keller Engineer's campus wide study.
Idaho State	Pocatello	073 Armory Building/Replace the heating boilers and associated steam/condensate/hydraulic lines	8	$ 669,900	

Master Plan
- Central Heating Plant -

prepared for

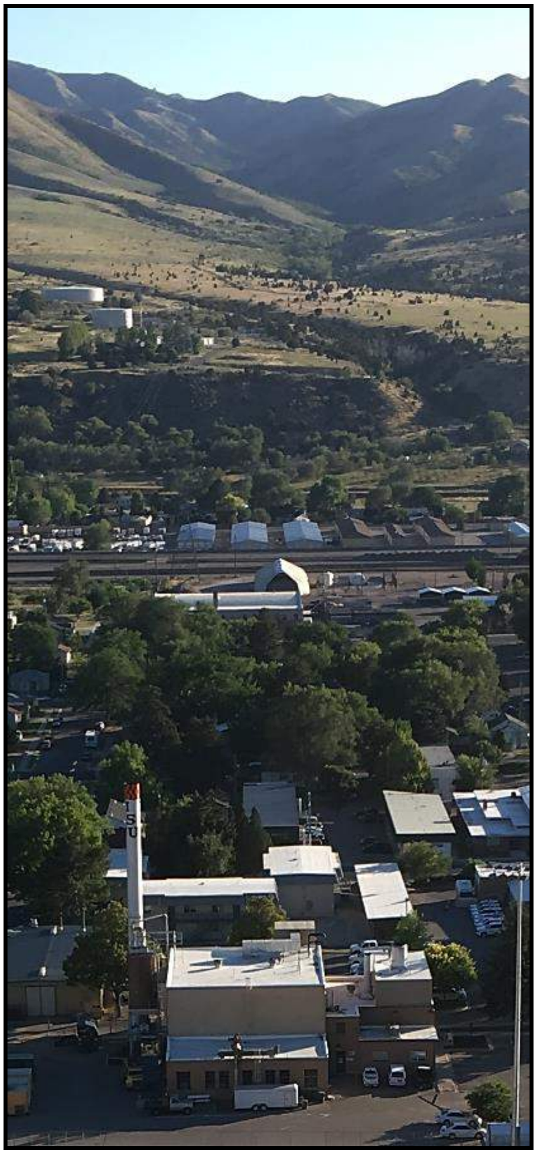
Idaho State University

September 13, 2021

engineering + design

Table of Contents

1. Executive Summary



ISU heating plant with the city of Pocatello and the foothills of the Bannock Mountains beyond.

This Master Plan is intended to serve as a guide for the Idaho State University's heating infrastructure for the next 30-40 years. The plan describes the strategy for maintaining a reliable and cost-effective heating system for all of the campus buildings connected to the campus loop. The specific strategy selected was developed as a collaboration between the design professionals and ISU Facilities Services personnel to be the most achievable and beneficial strategy out of many options that were considered. This document identifies individual construction projects necessary to execute long-term strategy and sets out guidelines for which buildings should be supported by the central plant in the future, and which buildings should have their own independent heating systems. In addition to the detailed description of the preferred path, this report also documents the alternatives considered and the factors that shaped the course of the Master Plan.

This Master Plan was requisitioned in a September 2019 RFQ. Much of the equipment in the existing heat plant has reached the end of its anticipated life, and it is time to consider the direction in which the campus wants to proceed with regard to its heating infrastructure. Considering what direction to take, it is useful to review what decisions other institutions have made. The body of the report includes brief descriptions of projects and proposals from other universities with steam heating systems. Examples include conversions to hot water heating, commitments to invest in steam or high temperature hot water systems, geothermal heat pump conversions, and campuses that have abandoned centralized heating systems for building-by-building systems.

The proposed Master Plan alternatives cover all these example scenarios and offer many different visions for heating campus with different advantages and disadvantages. A Choosing by Advantages (CBA) process was used to identify and rank important factors for the campus and then rate each option against these factors. Opinions of the probable costs of the various alternatives are also presented in the CBA. Multiple meetings with facilities services personnel, as well as further discussion and refinement of the CBA and details for each alternative, then took place in order to determine the preferred alternative on which the Master Plan was based.

The selected strategy is to continue to operate a steam distribution system and to invest in the central plant in its current location. This strategy leverages all the existing steam distribution system, the existing assets at the central plant such as Boiler #4 and the building itself. This strategy also limits construction costs to a reasonably achievable expected to be approximately 6.7 Million for the first phase and 12.5 Million for all phases. Three phases of construction are recommended to address deficiencies in the plant and distribution system. The first phase Would remove existing Boilers #1 and #2 from the original plant building. Once these boilers are removed seismic bracing would be installed to increase safety during a seismic event. A new boiler, capable of meeting the campus peak load, would be installed, becoming the primary boiler with existing Boiler #4 as a redundant backup and existing Boiler #3 as emergency standby. This phase would also include fuel oil infrastructure, and seismic bracing of some existing equipment. A phase is projected for the late 2020's to early 2030's to install another new boiler and new controls to carry the plant into the foreseeable future. The last phase addresses distribution and could be paired with either of the other two phases or developed as as separate project. Additional steam piping would be added to complete a loop in a section of the east campus distribution where several buildings are served by only a single branch pipe. Completing a loop in this area of campus would improve reliability and flexibility within the steam distribution system.

2. Introduction

2.1 Purpose

In September 2019, Idaho State University issued an RFQ to assess the condition of the central steam heating plant on the main campus of the University in Pocatello Idaho, and to develop a Master Plan for the plant and campus heating system. The Master Plan is required to evaluate and propose the future development of the heat plant building and equipment, investigate other possible locations on campus to locate a new heat plant, consider dual fuel and cogeneration, as well as anticipate technology change.

This report provides a roadmap for future development of the campus heat plant and heating system. It is the product of an investigation of the existing campus infrastructure, discussions with campus utilities personnel, and the consultant's experience working on other campuses. The report includes both the selected option and other options considered.

2.2 Steam system trends on other campuses

Steam heating systems are common on university and college campuses. Many of those systems are older than the system at Idaho State, and so we can see how these campuses have dealt with some of the same issues that ISU is currently facing. In addition to maintenance and capital cost considerations, many campuses have signed pledges committing to specific carbon and emissions reduction goals or have sought to be sustainability pioneers. Summarized below are several approaches that colleges and universities have taken in regard to their aging steam heating systems and the associated campus infrastructure. Some of the campuses listed below are clients of the consultant, and the engineers have direct knowledge of the systems and projects, whereas other examples are taken from industry articles and other publicly available information.

- **Brigham Young University Idaho:** The closest campus geographically to Idaho State, Brigham Young University has a steam distribution system that provides heating and domestic hot water heating. A new heating plant including natural-gas-fired boilers and a cogeneration system consisting of a gas combustion turbine and heat recovery steam generator was installed in 2015. This plant replaced an existing coal-fired heating plant. Furthermore, this past year a steam-turbine-driven chiller was installed at the central plant to take advantage of the otherwise wasted heat generated by the turbine during the low steam load summer months. The addition of the chiller transformed the campus system from a cogeneration to a trigeneration system. The focus of the campus remains squarely on steam heating from a central heating plant.
- **University of California System:** The University of California system has announced a Carbon Neutrality Initiative, which is a pledge to emit net zero greenhouse gases across its 10 campuses by 2025. Many other colleges and universities have set similar goals. As part of this initiative, UC Davis has started construction on their full campus steam to heating hot water conversion project.

- **University of Colorado at Anschutz Medical Campus:** This campus started as an army base in 1918. When the base was closed and the $5 billion-dollar medical campus was built on the site, the army's steam boilers were repurposed, as was some of the steam distribution system and a few utility tunnels. Since 2000, the central utility plant has constantly invested in steam infrastructure, growing the plant to a capacity of 420,000 lbs/hr. The campus has invested heavily in energy-efficiency projects as a way to delay steam plant expansions and to address energy and carbon emissions goals. Auxiliary plants have been considered at times but not constructed. A cogeneration system consisting of two gas combustion turbines and heat recovery steam generators was considered. Apart from capital funding concerns some on the campus' advisory board were concerned about investing in long life equipment designed to run on fossil fuels. The campus has never seriously considered converting to a heating water distribution system because of the value of the existing infrastructure and the steam use for sterilization, humidification, as well as heating in the campuses hospitals and heavy research buildings.
- **Auraria Higher Education Center:** This campus is located in downtown Denver and is a collaborative campus with buildings from a community college and two universities. The campus had been served by a district steam system run by the local utility company. This system was built in the early 1900's without condensate return, limiting its efficiency. The utility and maintenance costs of the aging steam lines and equipment led the campus to convert several buildings to stand-alone heating operation. In 2018, the campus asked for and received funding from the state to convert the remaining buildings on the steam system to individual natural gas boilers. The resulting project, now in the final stages of construction, extended the utility gas service to each of the buildings and installed new boilers in mechanical rooms, storage rooms, and new rooftop penthouses.
- **University of Utah in Salt Lake City**: The University of Utah in Salt Lake operates a high temperature hot water (HTHW) system in which water is heated to 400 degrees and kept under pressure to prevent it from becoming steam. Although not identical to a steam system, this type of campus heating system is similar, in that it requires fossil fuels. The University operates two plants, one serving the western academic part of campus and one serving the eastern medical campus. On the academic campus, the University has been investing in energy efficiency projects to reduce the loads on main HTHW plant while replacing aging boilers with newer equipment. On the medical campus, difficulties with the distribution system and requirements for healthcare facilities have led to many of the patient care buildings being decoupled from the HTHW loop. As the campus begins to consider pathways to reducing fossil fuel use and carbon emissions, the continued use of HTHW is being questioned. New buildings are being constructed apart with electricity as the only energy source and not connected to the HTHW loop, and options for reducing the water temperature for existing buildings are being considered to allow for future technology such as heat pumps to be implemented.

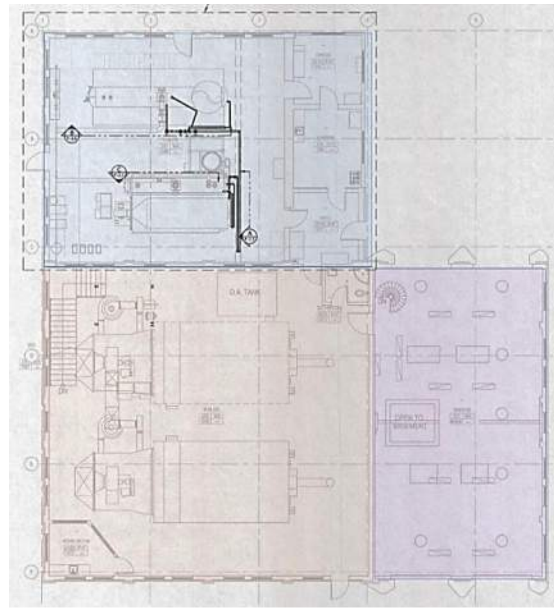
Several campuses with large focuses on carbon reduction and sustainability are in the process of installing geo-exchange (also called ground-source) heat pump systems to replace their steam systems. These systems are certainly the current hot trend, but they are also proven technology that have been operated for years drawing heat or cooling from the ground. The primary limitation of these systems is the temperature of heating water that can be produced. Most existing systems can produce 140-150°F degree water at best, while the newest heat pump technology is claiming up to 160°F. This is compared to 300-340°F for a steam system or 400°F for a HTHW system. The low heating water temperature presents two problems for existing campuses, the large distribution piping required to move both the ground source water and the low temperature heating water, and the requirement to retrofit much of the terminal HVAC equipment to provide sufficient heating at the lower temperatures. Despite these challenges the examples below show that many universities consider the systems to be an attractive option.

- **Colorado State University:** Located in Fort Collins, this campus is building a ground-source heat pump system for several of its buildings. The steam distribution system in this area of campus was in need of significant repair, and this project allows the University to decommission that portion of its steam distribution piping that is nearing failure. In addition, the University is limited by restrictions on emissions from its central steam plant but has plans to add new buildings to the steam loop. The new heat pump system enabled an increase in the total campus heating load without increasing emissions by displacing some of the steam use. To accommodate the lower heating water supply temperature produced by the heat pump system, only 130°F, a significant retrofit of the terminal HVAC equipment was required as well as modifications to the distribution piping.
- **Carleton College in Minnesota:** Carleton College will be the first to fully transition off steam when its current project is complete. The college was able to convert to a heating water system, with geothermal heating and heat pumps sized for the usual campus load and high efficiency condensing boilers and electric chillers installed to cover peak load times.
- **Colorado Mesa University:** Colorado Mesa University has also installed a ground-source heat pump system that distributes condenser water between buildings to balance loads. The system also uses condensing boilers and cooling towers to maintain the heat pump loop temperature during peak heating and cooling.
- **Miami University in Ohio:** Miami University Ohio is about halfway done with a project to convert their steam system to a hybrid geothermal heat pump and heating hot water system that will include several borehole fields, a thermal energy storage tank, condensing boilers, and heat pump chillers. This project also entails converting many buildings from steam to heating water.
- **Ball State University:** Ball State is in the process of installing one of the nation's largest ground-source closed-loop district heat pump systems to replace its aging steam system. New hot and chilled water piping distribution is being installed and many buildings are being converted from steam piping and coils to the heating water system.

3. Existing Heat Plant and Campus Infrastructure

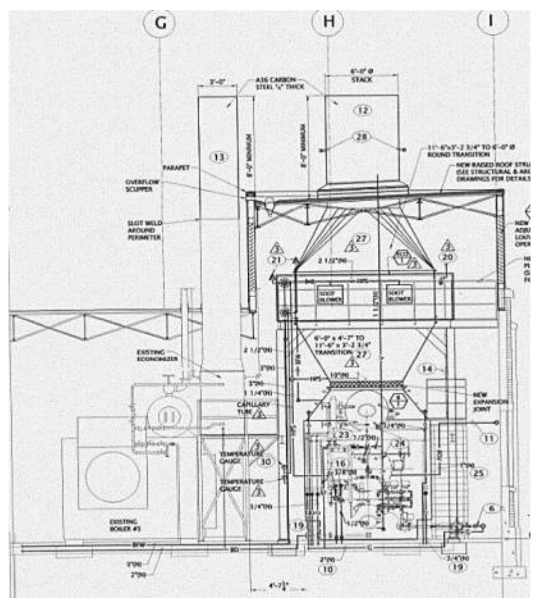
3.1 Heat Plant Facility

The heat plant consists of three main structures and a couple of small additions. The first is the original 1947 concrete and face brick building. This structure is approximately 34 feet tall above grade and has a basement level below grade. It houses Boilers #1 and #2 and the deaerator and condensate return equipment in the basement. Legacy coal bins, coal conveyance equipment, and ash hoppers below Boiler #2 still exist in this part of the building. Attached to the structure is a single-story garage space covering the coal bins that is now used for storage and workshop space. The last structure houses Boilers #3 and #4 and was reportedly built in 1957. This structure houses the control room, break room, and an attached addition that contains office space. The addition originally was about 20 feet tall, but part of it was expanded vertically in 2005/2006 to accommodate installation of Boiler #4.



Overall plan of the heat plant with the three main structures highlighted

The building is fairly spacious and provides adequate protection from weather for both equipment and facility and maintenance staff operations. The control room is small and not ideally located, as it is situated like a vestibule at the building entrance. With the removal of coal-handling equipment, there is significant unused space in the building. There are two baghouses located on the exterior that are no longer in use and should be removed as part of any major project at the plant.



Cross section of the building at Boilers #3 and #4

The building is not braced for a seismic event under current code. The risks from a seismic event would be immediate threat to the life safety of personnel in the plant and the risk to the heating system. A seismic event could render the equipment and piping system inoperative, cutting off heat to the campus. The risk to personnel is the primary concern because, apart from hospitals, very few buildings are built to resist a design-level seismic event and remain operational. The Rendezvous building, one of the newest on campus, is designed as a category II structure with an importance factor of 1.25, indicating that it is not intended to remain operational after a seismic event. It is unlikely, therefore, that the heating plant would need to be designed to remain operational as buildings on campus are not designed that way. It is anticipated that if the plant were to be constructed to under current code requirements I it would be a Seismic Design Category D structure.

3.2 Primary Heating Equipment

View of Boiler #1

Baghouse for Boilers #1 & #2

The heat plant includes four boilers, three of which are still functional. The input heat ratings and steam output for each boiler are listed in the table below alongside the maximum observed campus steam load.

Two of the boilers, Boiler #1 and Boiler #2, were installed in 1947. These are site constructed built-up, water tube, boilers, originally burning coal. Boiler #1 is decommissioned and disconnected from the system, and its burner has been removed. The burner for Boiler #2 is custom fit to holes in the fire box, and a cowling is fitted over the top of the burner during operation to cover the otherwise exposed flame. Boiler #2 is still operable and used by plant operators in rare circumstances. It is only required when Boiler #4 is offline, and Boiler #3 is not capable of meeting the campus load. The mortar between the bricks on the skin of the fire box contains asbestos, so the cost to demolish these boilers is significant.

The boilers appear to have been coal-fired, natural draft combustion at one time, but now they have induced-draft fans that pull combustion air through each boiler and force the flue gases either directly to the stack or through a baghouse on the west side of the building and then out the stack. Boilers #1 and #2 share the baghouse and common exhaust ductwork from the baghouse to the main stack on the south side of the building. The induced-draft ductwork and insulation have been tested and no asbestos was detected.

Boiler #3 is 63 years old, is of a more modern, factory-constructed, metal-skinned water tube design. This boiler has an economizer heating the feedwater and a forced-draft fan arrangement, and exhausts through an independent stack in the middle of the building.

Boiler #4 is 15 years old and manufactured by Victory Energy. It is more modern and of similar design to Boiler #3, with a forced-draft fan, water tube design, and stack economizer for feedwater heating. The burner on this boiler is also capable of being fired on #2 fuel oil. The fuel oil piping extends to the exterior of the building where a fueling station is located. This would allow fueling the boiler by truck, although the boiler has not been operated this way.

Boiler #2 Burner

3.3 Plant Auxiliary Equipment

In addition to the boilers, the heating plant houses auxiliary equipment for the steam system, as well as abandoned auxiliary equipment for coal handling. All of this equipment, with the exception of the abandoned coal-handling equipment, appears to be serviceable and is reportedly in good condition.

The water softeners and their controls are modern and located in the basement. There is no RO water system, the softened water is fed into the deaerator.

The condensate return tank and pumps that feed up to the deaerator are also located in the basement. This equipment has the potential to see chemical corrosion due to the aggressive nature of steam condensate. The equipment appears to be in good condition currently. Since the steam system is inactive over the summer, regular inspections of this tank should be performed. It is a fairly minor piece of equipment, but its failure would require the heat plant to run with 100% makeup water, reducing capacity.

Water softeners in the basement of the heat plant

Plant air compressor

In the 2005 project that installed Boiler #4, a new deaerator was installed just north of Boiler #2. The tank and feedwater pumps should continue to operate without excessive maintenance for an additional 15 to 25 more years assuming proper water treatment.

The air compressor is relatively new and located in the basement. It is a simplex unit with only one motor and one compressor. The compressed air system is now only used to support air power tools, and there are no longer any operational pneumatic valves in the plant. In 2016, a feedwater preheat system recovering heat from boiler blowdown was installed in the basement. This system is in good condition and is saving energy. The campus is reported to have a very good condensate return ratio, typically upward of 90%. This high return ratio is excellent from an energy standpoint, but it does limit the potential for the heat recovery system.

The abandoned coal handling equipment still on site is mostly located in the basement. It includes two coal hoppers, a couple sections of the old coal conveyers, and ash hoppers below Boiler #2. The hopper for Boiler #1 is already removed. This equipment takes up usable space in the basement.

The heating plant is monitored and controlled primarily by a modern PLC-based system by Allen-Bradley. The controls for Boilers #3 and #4 were updated in 2016. In addition to this system, there are direct-sensing/manual readout gauges in many locations, especially at the boilers. This is an ideal strategy because it provides the operators a reliable backcheck to the electronic sensors while still delivering the versatility of the computerized controls.

3.4 Secondary Heating Equipment

Secondary Boiler – Fieldhouse Building

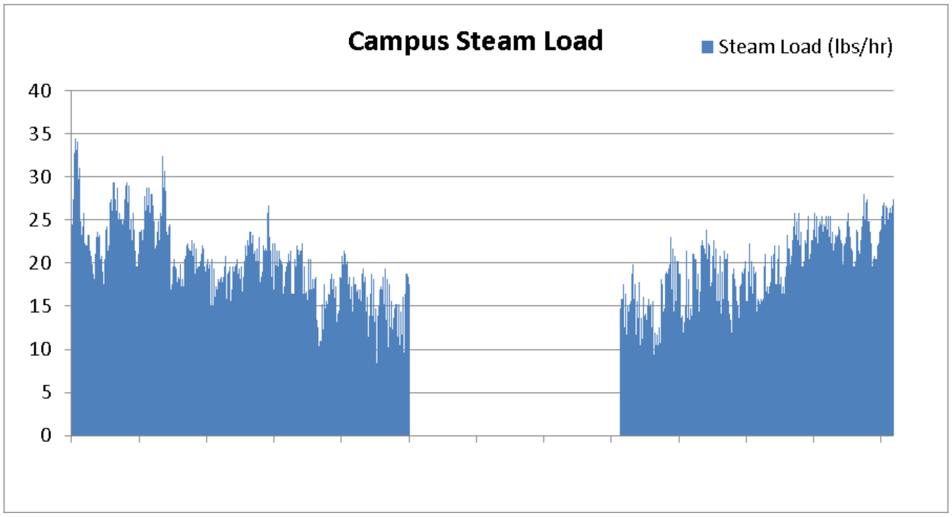
In addition to central heating plant equipment, there are five other steam boilers located in campus buildings and connected to the steam system inside those buildings. These boilers (listed in the table below) are used during summers when the main system is shut down. Theoretically they could be operated alongside the primary boilers and add their approx. 8,800 lbs/hr of steam output to the system. In reality, this is impractical, as these boilers operate in the buildings at pressures lower than the distribution pressure, behind the building PRV. As such they cannot feed steam back into the distribution piping and their output is limited to only the boiler in which they are installed. Even to operate the local boilers in parallel with the central steam system would require additional controls and automated valves to balance loads between the local and central boilers.

Steam System Assets				
Designation	**Location**	**Age**	**Condition**	**Output (lbs/hr)**
Boiler #1	Steam Plant	73 years	Inoperable	20,000
Boiler #2	Steam Plant	73 years	Poor	20,000
Boiler #3	Steam Plant	63 years	Fair	20,000
Boiler #4	Steam Plant	14 years	Good	60,000
Boiler S1	Reed Gym	15 years	Good	2,821
Boiler S2	Turner Hall	56 years	Fair	2,273
Boiler S3	Gale Life Science	15-20 years	Fair	2,760
Boiler S4	Rendezvous	8 years	Good	2,330
Boiler S5	Pond	15-20 years	Fair	1,410

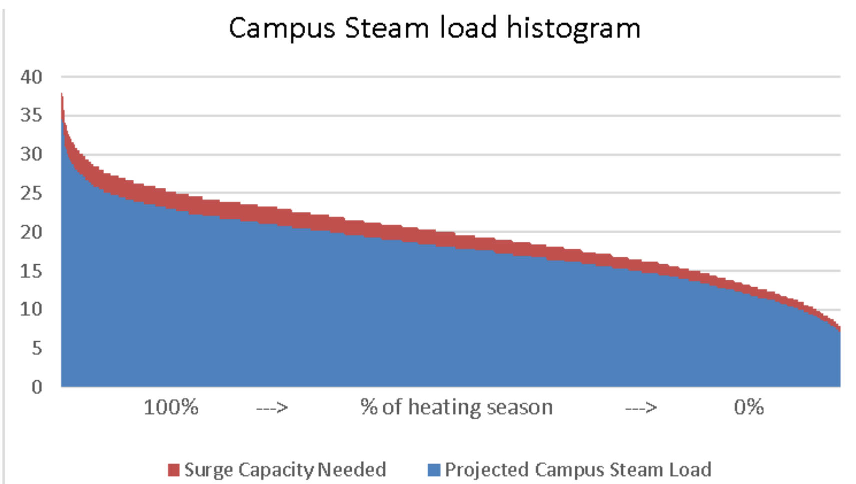
3.5 Heating Distribution System – Campus Load

Based on data supplied by the heating plant log, the campus steam load has been modeled in order to analyze potential options and needs. The heating plant log only manually records boiler output and temperature every 2 hours. While this is invaluable data and can stand as a firm basis for analysis, some extrapolation is required. In addition, the steam consumption of each building is not known, as there are no meter readings from those individual buildings. The analysis, based both on the data and engineering judgement, coincides with data and information that RMH received on site. The typical annual maximum steam load for campus is around 40,000 lbs/hr, with up to 45,000 lbs/hr seen during rare extreme cold (-20°F) weather events. Note that the charts on the following page were developed from 2 hour interval steam data. As such they do not capture shorter peak values, especially during early morning warmup, and so the peak steam demand appears to be lower the charts.

The Campus Steam Load chart in this section shows the steam required by campus and supplied by the central plant. The profile is built on a typical year's weather and starts in January on the left and ends in December on the right. The central steam system does not currently operate in the summer, and so the load in June, July, and August is shown as zero. In fact, there is still a steam load during the summer that is served through the secondary heating equipment. We therefore know that the summer load is less than 8,800 lbs per hour, the sum of the outputs of all the secondary steam boilers. In actuality, the peak summer load is probably somewhere between 5,000 and 6,000 lbs per hour once load diversity is accounted for. The raw data indicates that the minimum output from the heat plant while it is operating is around 7,200, which would include whatever minimal load is on the system plus a significant amount of steam required to keep the distribution system up at temperature.



A second way of displaying load is to arrange the data from peak to minimum load. The histogram shown below makes it easy to see that the campus load is between 10,000 lbs per hour and 25,000 lbs/hr for the vast majority of the year. Also shown on this curve is an increased demand of 10% to surge capacity when the heat plant needs to makeup from a disruption or an outage. This additional capacity is critical to consider when sizing equipment.

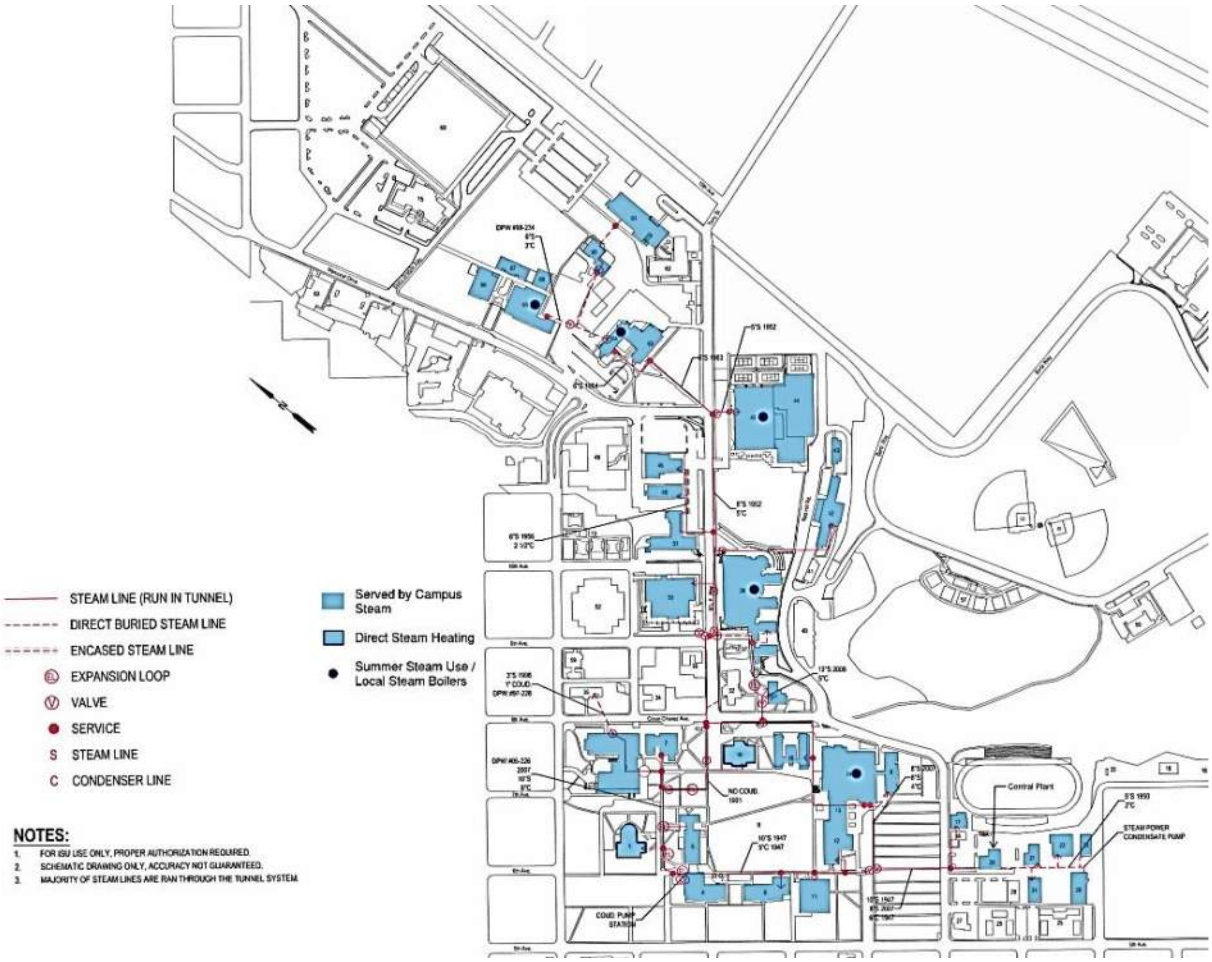


The steam serving each of the buildings on the campus system is not individually metered, so individual building heating loads are not known. To evaluate future heating system options, building heat loads were estimated based on building square footage, type, and observed heat loads at similar facilities in similar climates. The table below summarizes the estimated heat load per building. A larger version of this table is included in the appendix. The table in the appendix displays all campus buildings and estimates total campus heating load (including buildings not on the steam system). The difference between the total campus steam load in the table and the maximum observed plant output is the estimate distribution losses in the steam piping to the buildings, and plant parasitic loads.

Building Number	Building Name	Type	Type for Heating Calculation	Stories	Square footage	Envelope Sqr ft	On Steam?	Heat	Heat Load	Steam Load	Steam lne size
							Y/N	Btuh/sf	MBH	lbs/hr	"
38	Rendevous (see housing belo	Mixed use/Commor	Assembly/Multi-purpose	3	231526	321000	Y	25.29	5856.33	5685.76	
3	Physical Science - Complex	Class/Lab	Classroom	3	154471	176542	y	23.00	3552.06	3448.60	
65	Biology (Gale)	Lab (1+4 story)	Lab	3	84673	95538	Y	40.24	3407.35	3308.10	? <6
50	Library - ELI M Oboler	Library	Library	3	163513	173414	Y	20.70	3383.98	3285.42	4
14	Student Union & Bookstore		Assembly/Multi-purpose		129595	142760	Y	25.29	3278.04	3182.56	
45	Reed Gymnasium		Assembly/Multi-purpose	1	108122	132658	Y	25.29	2734.89	2655.23	5
44	Student Rec Center		Assembly/Multi-purpose		89088	98197	Y*	25.29	2253.44	2187.80	
5	Business Administation		Classroom	4	93534	104316	Y	23.00	2150.81	2088.17	6
12	Museum	Musueam/Office	Assembly/Multi-purpose	4	69076	76223	Y	25.29	1747.24	1696.35	
11	Fine Arts	Class/Performance	Classroom	3	75335	91307	Y	23.00	1732.33	1681.87	3
4	Liberal Arts - Kegel	Classroom	Classroom	3	58952	65832	Y*	23.00	1355.60	1316.12	
63	Garrison Hall	Office (former res h	Office	7	76826	83794	Y	16.10	1236.63	1200.61	
64	Turner House	Housing - Dorm	Residence		68065	77315	Y	16.10	1095.61	1063.70	
7	Engineering - Lilibridge	Class/Lab	Lab	2	27038	30346	Y	40.24	1088.04	1056.35	4
8	Pharmacy - Leonard Hall	Class/Lab	Classroom	2.5	43255	49275	Y	23.00	994.65	965.68	4
51	Trade & Technology		Classroom	1	41551	45347	Y	23.00	955.47	927.64	4
15	Graveley Hall	Office (former res h	Office	3	49939	57682	Y	16.10	803.84	780.43	
1	Frazer Hall	Classroom	Classroom	2	32683	45663	Y	23.00	751.55	729.66	6
42	Owen Redfield Complex	Housing - Dorm	Residence	3	41967	47237	Y	16.10	675.52	655.85	6
61	Albion Hall	Classroom	Classroom	2	28156	27139	Y*	23.00	647.45	628.59	
10	Administration	Office	Office	3	38542	43439	Y	16.10	620.39	602.32	?
6	Early Learning Center	Daycare	Classroom	2	23501	26213	Y	23.00	540.41	524.67	
46	Vocational Arts		Classroom	1	23180	25649	Y*	23.00	533.02	517.50	
66	Nursing - Beckley	Office	Office	1.5	30109	33823	Y*	16.10	484.65	470.53	
69	Plant Sciences	Greenhouse	Lab	1	9126	9701	Y	40.24	367.24	356.55	
68	Speech Pathology - Audiology	Office/Classroom	Classroom	2	15531	17781	Y*	23.00	357.14	346.73	
31	Student Health Center		Classroom	2	12162	13813	Y	23.00	279.67	271.52	1.5
49	Estec	Shops	Storage/Shops	2	19656	21263	Y*	11.50	225.99	219.41	
20	Heat Plant		Office		13048	19578	Y*	16.10	210.03	203.91	
13	Hypostle		Assembly/Multi-purpose		7921	8729	Y*	25.29	200.36	194.52	
67	Lecture Center		Classroom		8364	12055	Y*	23.00	192.33	186.73	
43	Dyer Hall	Housing - Dorm	Residence		11193	12487	Y*	16.10	180.17	174.92	
22	Ships		Storage/Shops		12983	14014	Y*	11.50	149.27	144.92	
26	Shipping and Receiving - shops		Storage/Shops		11578	20024	Y*	11.50	133.12	129.24	
21	Transportation services shop		Storage/Shops		6840	11200	Y*	11.50	78.64	76.35	
17	Davis Field House	Field	Storage/Shops		4401	5825	Y	11.50	50.60	49.13	2.5
38	Rendevous (see above)	Housing Apartment	Residence				Y	16.10	0.00	0.00	
23	Bengal Depot						Y*		0.00	0.00	
24	Custodial/Welding						Y*		0.00	0.00	
				Steam System Total:	1,915,500.00				44,303.86	43,013.45	
				Campus Total:	2,422,553.00				55,792.41	54,167.38	
				Campus BTU/sf	23.03						
				Steam system BTU/sf	23.13						

3.6 Heating Distribution System – Campus Loop and Steam Tunnels

Steam is distributed throughout the campus and condensate returned in a series of tunnels and direct-buried pipes. The map below shows the steam distribution piping and identifies which buildings are served by the campus steam system. A larger version of this map is located in the appendix.

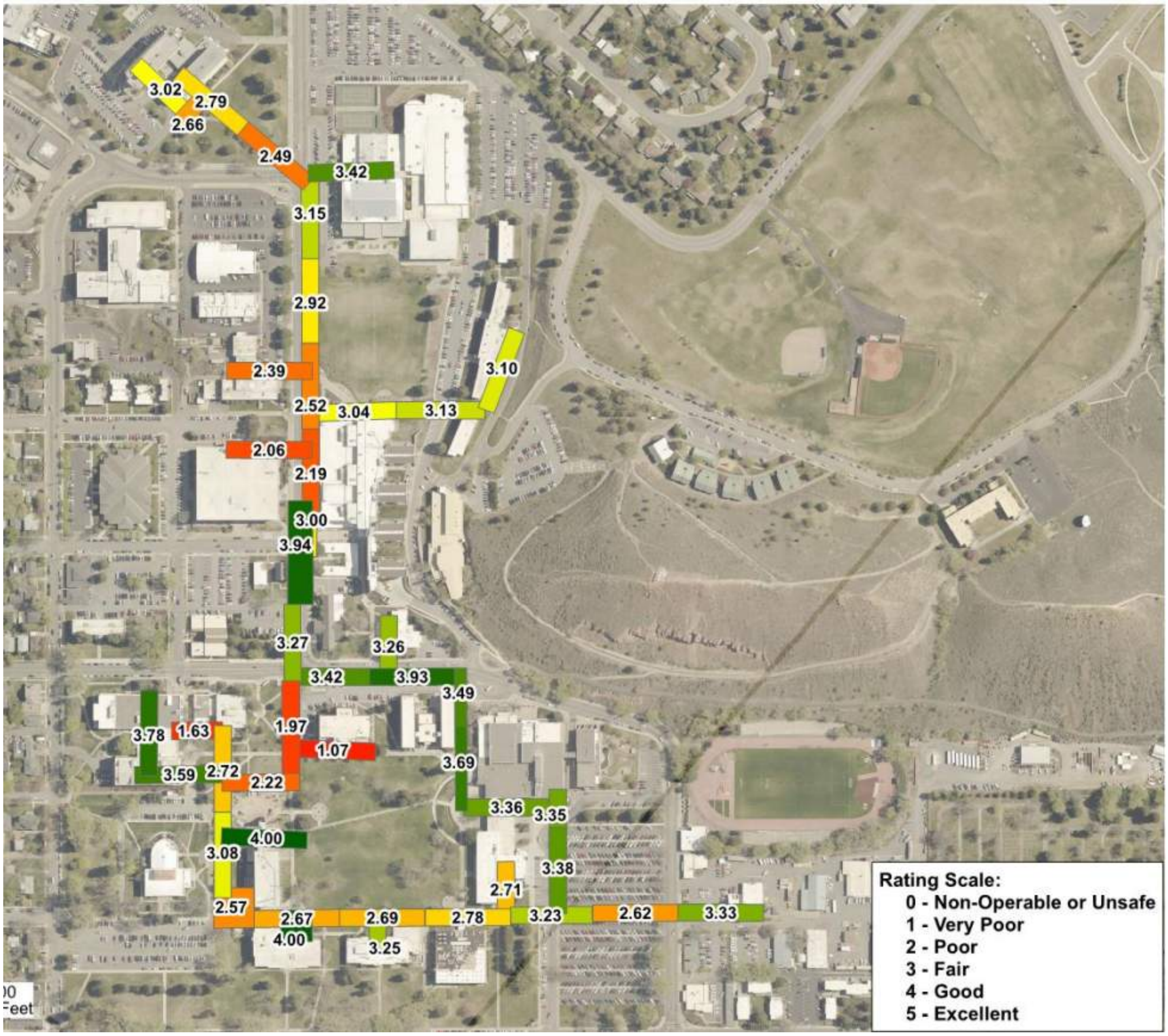


Campus Steam Distribution and Connected Buildings

The campus does not meter steam use in individual buildings, so the actual path the steam takes once it leaves the plant and the building in which it is consumed is unknown. To attempt to identify where system capacity might be abundant or scarce, we have estimated the individual building loads based on building size and occupancy type. The estimated loads and main steam piping capacities are illustrated on the campus map on the following page. The map shows that the steam mains have sufficient carrying capacity to accommodate the current campus loads and connected buildings with additional capacity available in much of the system for additional buildings. A larger version of this map is included in the appendix.

Campus Steam Piping Capacity and Connected Building Loads

In 2018, a tunnel survey and study were done to identify future projects and plan for anticipated maintenance costs for the aging tunnels and the utilities, including steam and condensate, routed within. The tunnel sections were rated based on need (see figure on the following page) and 10 years' worth of prioritized projects were recommended and given opinions of probable cost. The total cost was about $8,900,000, not including the cost for smaller maintenance type items. This is a significant investment that should be considered in evaluating the future of the heat plant. It should be noted that the main campus electrical feeders, telecommunication cables and other utilities are also routed in many of the existing tunnels, so even if the steam system were abandoned, the other utilities would still require those tunnels to be maintained.



Map of Tunnel Ratings from 2018 Tunnel Assessment Final Report

Besides the age of the steam distribution infrastructure and tunnels, other main system liabilities are single points of failure in the steam distribution piping system. For utilities like steam and electrical service, where a prolonged outage can potentially series damage to facilities, the ideal distribution is a loop so that a failure sustained at any one point will not endanger service to all buildings downstream. As seen in the previous campus maps, a portion of campus is served by a loop, but the east area of campus is fed from a single main pipe run. Any failure in that section of tunnel or piping would cause a heating outage for buildings east of the disruption. The high and medium load buildings that could be affected include the Library, Reed Gym, the Student Recreation Facility, Garrison Hall, Turner House, and the Gale Life Science (Biology) building. This vulnerability is increased when the age and condition of the steam distribution infrastructure are taken into account. In 2007, an additional main steam line was added leaving the heat plant in order to address the vulnerability of a single point failure causing a campus wide outage, but east campus remains vulnerable.

3.7 Heat Plant – Electrical

The heat plant power includes a three-phase, 208-volt utility transformer; the service entrance switchboard is rated for 1600 amps. It was installed recently and has spare capacity and available breaker space. The plant loads have been operating on a 600-amp circuit from that switchboard.

The 600-amp circuit feeds a fusible switchboard "M" that in turn, serves a motor control center (MCC) and two 400 amp switchboards. Most of the circuits in the MCC are not used due to the discontinued use of coal. Switchboard M is backed up with a natural gas generator and an automatic transfer switch that will automatically transfer the system to generator backup power when utility power is down. The generator is served by utility-supplied natural gas, and there is no onsite fuel source. This approach assumes it is very unlikely that both electrical and natural gas services will be disrupted at the same time. In the case of a regional power outage this may not be the case.

The original electrical distribution system was designed to serve an older facility configuration where there were many more direct-fed motors with across-the-line starters and fewer variable speed controls. Over the years, the load profile has changed considerably with variable frequency drives (VFDs) and electronic controls becoming much more prevalent. This new load profile renders the existing MCC obsolete. There is much less need for MCCs, and large fusible switchboards. At the same time, there is a greater need for smaller branch circuits and power quality accessories.

Service entrance pull box (right) and shelter conduit entrance into the basement

The power service conductors and the feeder conductors to switchboard "M" share an outdoor junction box, as this was the service feeder pull box at one time. It appears that the pull box may not be adequately sized for all these conductors. At the time of the 1600-amp service switchboard installation, the existing underground conduits and wall penetrations were apparently reused as much as possible. This created a configuration where the pull box has more conductors than when originally designed, and the conduits going into the basement share a sheet metal shelter with the incoming gas line. This is not an immediate hazard, but maintenance may be more difficult.

Panel M, the MCC, Panel P, and Panel PA, are energized, but they are approaching the end of their design life, and it will become more and more difficult to obtain parts such as breakers, that properly fit. One of the hazards involving older equipment like this is the degradation of the parts that remain. This presents an arc flash hazard if a fault occurs when a breaker is closed, or if the breaker fails catastrophically. When screws are missing and covers are bent the arc flash is not contained, which is a life safety hazard.

Loose and corroded dead-front covers will not contain arc flash events

Branch circuit Panel 'L' on main level (filled with breakers)

Small branch circuit panels are installed throughout the facility and appear to be in adequate condition. There is no spare capacity in these panelboards; however, a small percentage of these circuits have been abandoned and could serve as spare circuits.

Customer-owned metering for the building is at the main transformer outdoors. Plant power usage is manually recorded on a monthly basis. Power for all building loads is served through the transfer switch, so the building demand equals the demand that is on the generator in the case of a utility outage. There was no automatic load shedding sequence observed.

3.8 Campus Electrical

The campus is interested in the feasibility of installing a cogeneration, or combined heat and power, system. To evaluate this, RMH needed to understand the campus power distribution. This section reports the findings of the Engineer's investigation of that system.

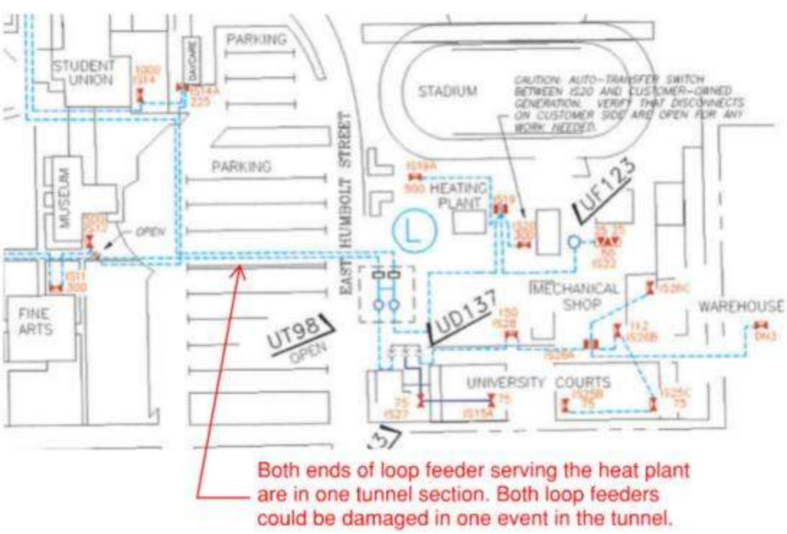
Customer electronic meter in utility socket

The electrical infrastructure delivering utility power to the buildings of Idaho State University is a 12.5kV medium-voltage distribution system owned and operated by the local utility company, Idaho Power. At one time it appears to have belonged to the University and then sold to the utility many years ago to maintain the system. The building services observed had utility style meter sockets installed at the service transformers. These sockets had owner electronic metering designed to be installed in a standard meter socket. The owner manually checks these meters on a regular basis. The utility maintains the medium-voltage switching and building transformers, even though the primary meter is at the power entrance to the campus. The power billing schedule is Primary Time-Of-Use Rates (Schedule 19, IDP). Along with the rate charge there is a facility charge added to the bill to maintain the campus distribution equipment.

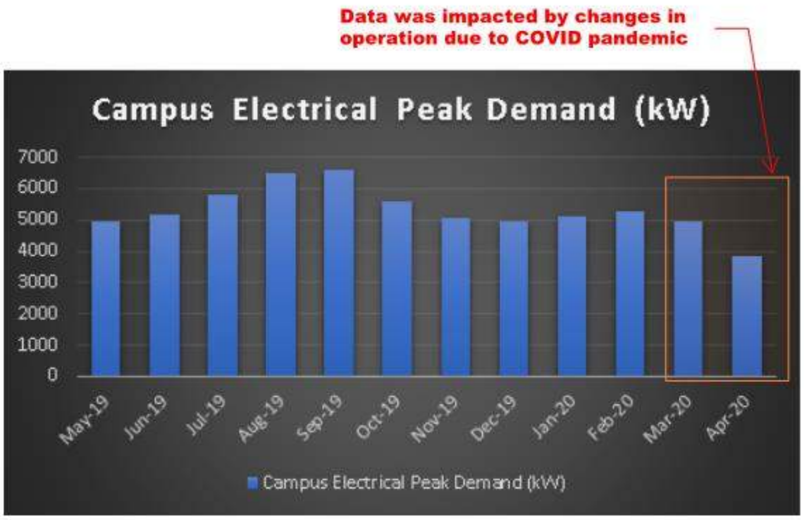
The utility power is metered at the primary service entrance to the campus. There are two main switching line-ups on the campus, the main switchgear is in the underground H vault. The K switchgear is outdoor mounted on the northeast side of the Quad. These two line-ups form a loop system that adds reliability to the University power source. These switchgear line-ups serve the building transformers with loop feeder circuits such that other buildings on the circuits can be energized even if one switch is down and isolated. The system appears to be very reliable and well maintained.

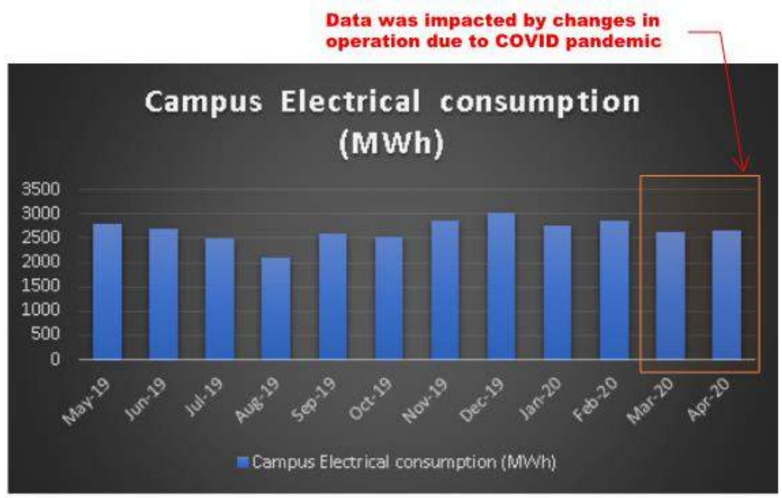
Switchgear line-up K

The feeder serving the Heat Plant is part of a feeder loop, however, both loop feeders are in the same tunnel section and therefore subject to a single-point failure in the tunnel. The conductors are protected in separate cable trays and are mounted on the opposite wall of the tunnel across from the steam piping, both conditions help add protection for the cable.



The charts below show the aggregated consumption and peak demand for campus. This information was used to develop the initial sizing of cogeneration (or combined heat and power) systems.





4. Master Plan Considerations and Decision-Making Process

4.1 Goals and Process

The Master Plan for the University's heat plant and campus steam system was developed as a roadmap to meet the campuses needs with a time horizon of 50 years. A list of the goals identified during discussions with the campus utilities staff is presented below. The list is in descending order of importance:

- Reliably generate heat.
- Reliably distribute the heat to campus.
- Avoid single points of failure.
- Operate on multiple fuel sources.
- Minimize carbon emissions.
- Minimize utility costs.
- Minimize maintenance costs.
- Minimize costs to construct future campus buildings.
- Flexible solution, most adaptable for future technology change.
- Reduce nitrogen oxide (NOx) emissions.
- Maintain a small footprint on campus.
- Minimize impact and renovations required in buildings.
- Construct a "showpiece" project.

After the July site visit and development of the steam plant assessment and immediate needs report, different potential options for the heat plant and campus steam system were explored and evaluated. Based on our prior experience with campus steam systems, the current trends on other university campuses, the condition of the existing steam system assets and discussions with ISU personnel, multiple alternatives were considered and evaluated for the future of the university's steam system. The considered alternatives are detailed in Section 6 "Master Plan Alternatives Considered."

4.2 CBA Results

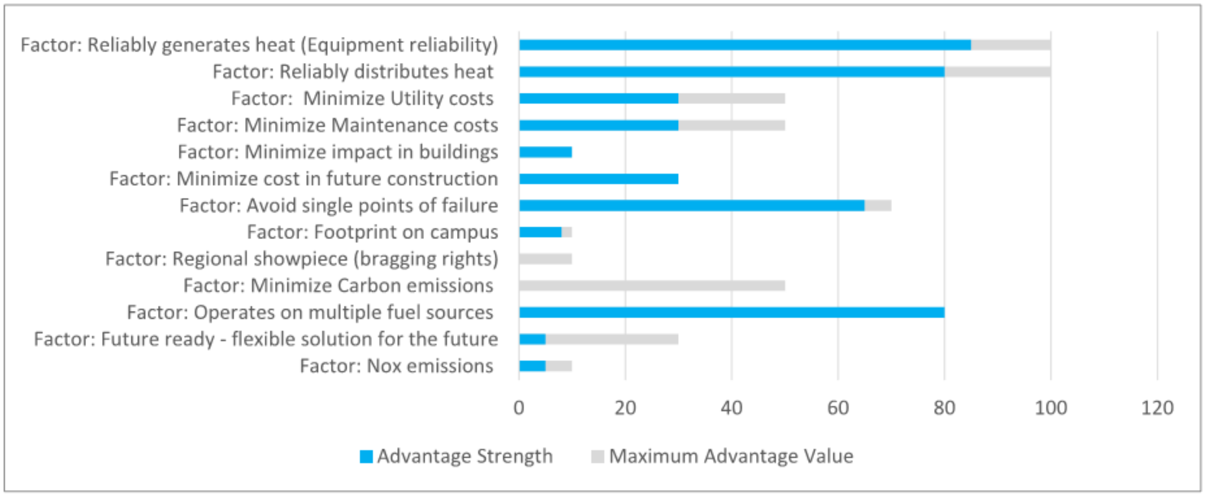
A "Choosing by Advantages" (CBA) analysis of the alternatives was performed by the RMH Group and the key players at the University. The results of the CBA indicated that alternatives "Invest in Steam – Current Plant" and "Central Hot Water – Day 1" were the most promising to the group. A summary of the CBA is presented below with the full table in the appendix. The total importance score shown in the table should be read as the degree to which the group believed that each concept would meet the goals and priorities of the campus.

Choosing By Advantages Study of:				
ISU District Heating System	**Invest in Steam, Current Plant**		**Invest in Steam, Aux Plant**	
	Commit to maintaining the steam distribution system and connecting new buildings built within 500ft of existing lines, invest in the current plant		Commit to maintaining the steam distribution system, connecting new buildings within 500 ft of a main. Build an Auxiliary plant to supplement the main plant	
Total Importance		428		430
Capital Cost	$8,399,000		$10,872,000	

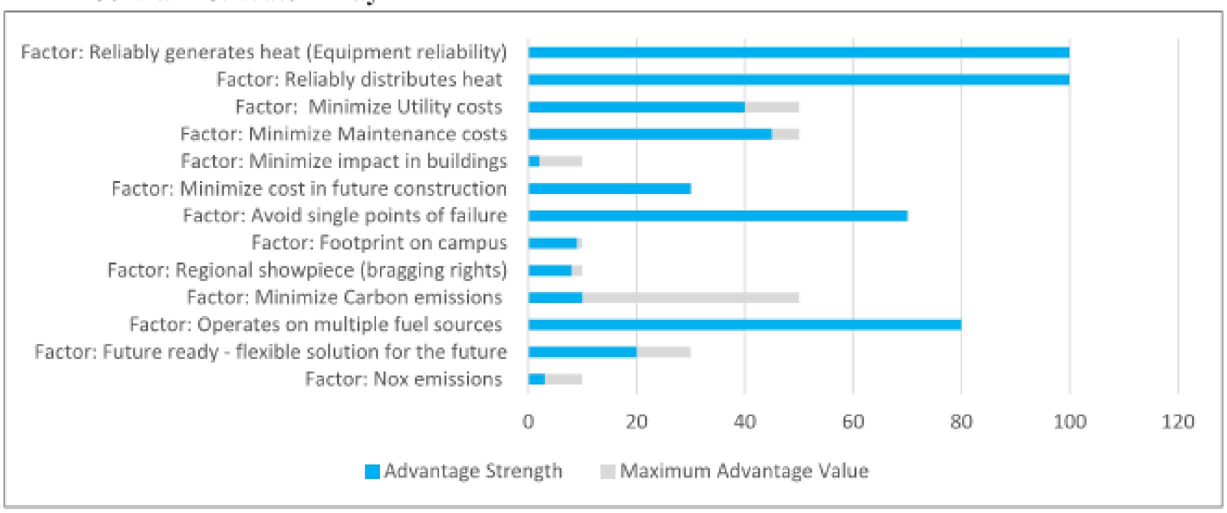
Move to Distributed Heating		**Central Hot Water -incremental**		**Central Hot Water - Day1**	
Maintain existing steam system while new buildings and major renovations have their own heating systems, prune steam lines from distribution system as possible		Maintain the existing steam system while building a new scalable hot water plant and distribution that would be scaled up over time		Rebuild the steam plant into a hot water plant, provide new distribution, renovate buildings to remove direct steam use where or add steam generators where needed	
	338		434		517
$33,453,000		39-44 Million		$41,809,000	

Heat pump Systems -incremental	
Build, and then expand, a heat pump heating system. Renovate buildings for 140 degree heating water	
	445
$59,000,000	

Invest in Steam, Current Plant



Central Hot Water - Day1



4.3 Budgeting Process

Additional working sessions and discussions with other stakeholders not involved in the initial discussions were required in order to make a final selection. While a conversion to central hot water on day one scored the highest in the CBA, the University later identified funding constraints that resulted in selecting the option of investing in steam at the current plant. This path meets the campus requirements of reliably providing heat for the coming 40-50 years while also being a cost-effective solution.

5. Heat Plant Master Plan

5.1 Overview: Invest in Steam – Current Plant

The selected path maintains steam as the heating medium for campus and builds on the existing heating plant and existing heating distribution system. New heating equipment in the existing heat plant building would increase reliability and improve maintenance and efficiency. Additional steam distribution would eliminate some single points of failure. A liquid fuel system would provide on-site fuel storage to guard against an interruption in natural gas service and potentially allow for fuel cost savings on an interruptible gas service.

There are several advantages of investing in the current steam plant. First, there are several assets already in place, such as the newer Boiler #4 and the new deaerator system that would continue to be used. Second, while requiring significant maintenance, the steam/condensate tunnels and buried piping provide an existing distribution method and the tunnels support the routing of other utilities. Third, the plant is in a good location on campus, which allows condensate to fall by gravity back to the plant. Furthermore, the plant does have the physical space available to be remodeled or expanded if campus needs increase. Investing in the steam plant would keep maintenance centrally located as opposed to distributed stand-alone heating plants. In addition, investing in the current steam system and heat plant has lower capital investment costs than building a new system or a new plant. Finally, outside of the heat plant, no building retrofits or changes would be required since the campus would stay on a steam system. Because many buildings use steam directly in their heating systems (vs using a single heat exchanger to make heating water for the building) retrofitting those buildings to be compatible with a hot water heating plant would be both expensive and disruptive.

5.2 Heat Plant Modifications

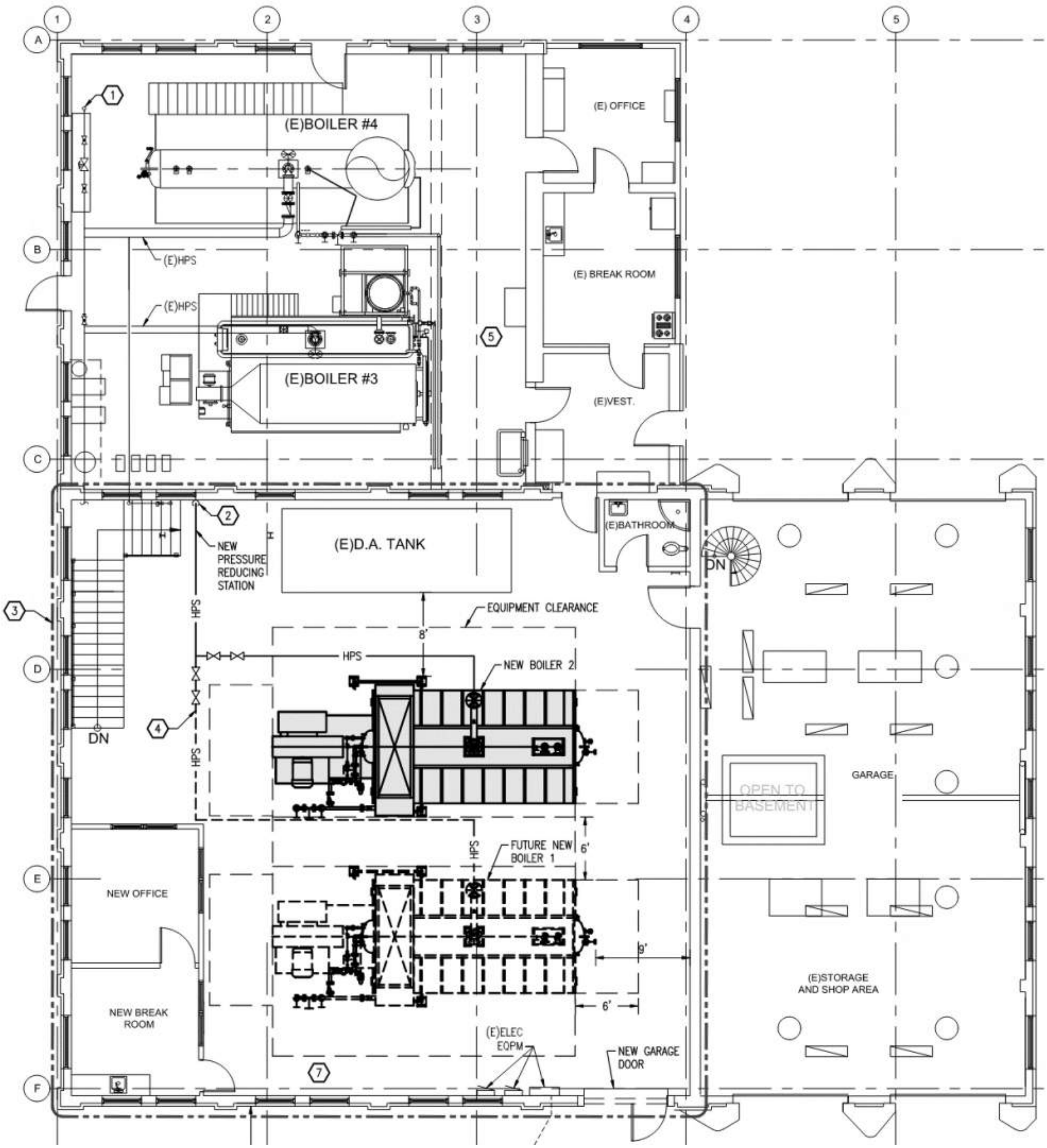
5.2.1 Primary Heating Equipment – Addition of Industrial Boilers

One new industrial style 50,000 lb/hr (pph) boiler would be installed to provide N+1 boiler redundancy that does not rely on boilers older than their anticipated useful life (Boilers #2 and #3). The new boiler would operate as the primary campus boiler with Boiler #4 as backup and Boiler #3 as emergency standby.

The current peak campus steam load is approximately 45,000 pph, and as the campus is not anticipating any growth to the steam system, a 50,000 pph boiler would be able to cover the entire campus load and fully back-up Boiler #4 without relying on other older boilers. This size boiler should also be capable of modulating output down to the minimum campus load of 7,200 pph without the need for a pony boiler. The preferred location for the new boiler would be in the original section of the building that currently houses Boilers #1 and #2.

In 5-10 years, Boiler #3 will no longer provide reliable emergency backup due to age. In addition, Boiler #3 does not have the capacity to cover the entire campus steam load by itself, and Boiler #2 is already past its life expectancy. Therefore, a second industrial 50 Mlb/hr boiler should be installed within a 5–10-year timeframe. This installation would provide N+2 redundancy to the campus with three boilers each able to cover the campus steam load individually. The second large boiler should also be installed in the original section of the building that houses Boilers #1 and #2.

Since both Boilers #1 and #2 will require asbestos abatement, removing both boilers at the same time would decrease abatement costs. Removing both boilers at the same time would also enable the original building to be seismically retrofitted more cost effectively than would be possible working around existing equipment. With, both boilers removed the first 50 Mlb/hr boiler could be installed in Boiler #2's current location. With a future boiler in the old Boiler #1 location. As part of the first 50 Mlb/hr boiler install project, all of the piping for the second 50 Mlb/hr boiler should also be installed up to isolation valves. This would allow the second boiler to be installed without a steam system shutdown and would also allow a temporary boiler to be connected to the system if needed.



Heat Plant Mechanical Plan showing install of 1st new boiler (Phase 1)

The new boilers would be O-type industrial watertube boilers similar to Boiler #4. Cleaver Brooks boilers are shown as the basis of design in the heat plant drawing above. The boilers would have stack economizers for feedwater heating and low NOx burners. Ultra-low NOx burners and SCR equipment are available as options if emissions requirements change in the period between this Master Plan and the construction projects for these boilers, particularly the future Boiler #1. The boilers would be capable of operating with #2 fuel oil as well as alternative fuels such as renewable natural gas, biogas and hydrogen with modified or replaced burner assemblies. The new boilers and their piping would be braced for a seismic event per code, Seismic Design Category D, with a 1.0 importance factor.

5.2.2 Modifications to Heat Plant Building

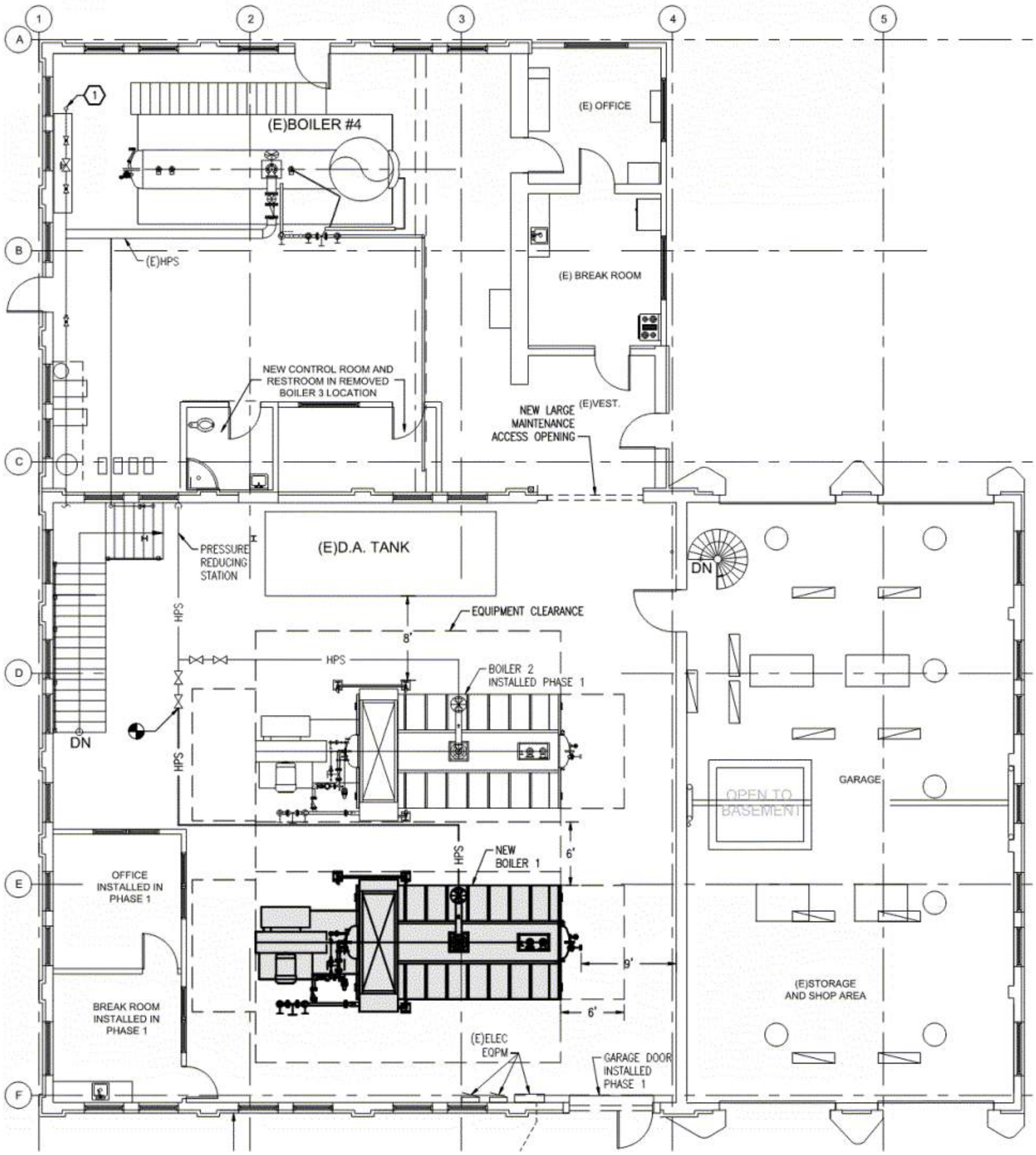
The two new large boilers would fit in the original portion of the heat plant. However, the boilers would need to be craned in through the roof.

As part of the first boiler installation project, the original portion of the building should be seismically braced. The existing building structure is board formed concrete with exterior face brick. A detailed design study and determination of existing reinforcing inside the concrete would be required to develop a seismic bracing strategy. All interior bracing should be completed prior to installing the new boiler and piping mains. Seismic measures for the exterior of the building can be differed if the structural design study determines this work can be completed separately from the rest of the building reinforcing.

Building a new seismically braced addition to the north of the plant was considered over retrofitting part of the existing building, but the University did not want to expand the heat plant towards main campus, and the addition would have been more expensive than a retrofit if the retrofit is completed primarily while the building portion is empty. In addition, the removal of Boilers #1 and #2 would be included regardless of whether a new addition is built or whether the existing plant is retrofitted.

During the seismic retrofit, we recommend adding a new large garage door to the south wall of the 1947 portion of the plant to simplify installation and removal of large equipment. Additional office spaces could be added along the west wall of the plant as relocations for the existing office and break room that are experiencing structural foundation issues. These spaces would be easiest to add while this section of the plant is already under construction.

During the second new boiler install project, boiler #3 would be removed and a control room and restroom constructed in its place. This would also allow for a large opening or garage door to be installed between the original plant and the addition which would provide improved maintenance access by creating a wide path from the outside to the original and addition portions of the plant.



Heat Plant Mechanical Plan showing install of 2nd new boiler (Phase 2b)

5.2.3 Addition of Back-up Fuel System

To increase campus resiliency in the event of a natural gas outage, a #2 fuel oil system should be installed to provide fuel oil to Boiler #4 and new Boilers #1 and #2. The tank would be at least 5,000 gallons, which would enable boiler operation for 14 hours at 40 Mlb/hr. A concrete-encased above-ground tank could be installed to the south of the plant once the existing stack and coal silo are removed. A day tank inside the plant should also be considered to allow warmer fuel during a cold start. In addition, the University should consider a service agreement for fuel oil to be delivered within 12 hours.

5.2.4 Modifications to Plant Auxiliary Equipment

Since the components of the feedwater system are relatively new and in good condition, the only modification required to the feedwater system would be to seismically brace the equipment and associated piping systems. This would afford some protection from a seismic event and provide a completely braced system since the new boilers would be seismically braced as well as the original building that houses the new boilers and feedwater equipment.

The burners for the new boilers would likely require compressed air for fuel oil atomizing when they are operating on back-up fuel. Therefore, an industrial duplex air compressor should be installed to provide redundancy to this system. The system could be located in the basement and should also be seismically braced. Permanent compressed air piping would be installed from the new air compressors to new boilers #1 and #2 as well as existing boiler #4.

The condensate tank appears to be in good condition and is not likely to fail in a catastrophic manner that cannot be managed. Despite the low risk, it would be beneficial to install a second receiver or valves to bypass the tank in an emergency and allow condensate to be fed directly to the deaerator until the tank can be replaced. It should be noted that this work is a lower priority than the items discussed in previous paragraphs, as the system could operate at 100% makeup if the condensate system were compromised for any reason. The proposed condensate equipment work could be done during the summer so that no outage to the system is required. The condensate receivers should also be seismically braced as part of this work.

The first new boiler would be connected to the existing plant PLC control system. In 5-10 years, the control system would be nearing the end of typical system life and would likely need a major upgrade or replacement. This controls work is envisioned as part of the installation of the second new boiler so that the new boiler could be connected directly to the new or upgraded control system. Furthermore, as part of the second boiler project, boiler #3 would be removed and a new control room could be built in its location so that the controls could be relocated from the vestibule at the same time as the system upgrade.

5.2.5 Emergency Power Modifications

While it is unlikely that both electrical and natural gas services would be disrupted at the same time, this is a possibility with a regional power outage, which could take down local gas utility equipment. For this case, the University should consider replacing the existing natural gas generator with a fuel oil generator to improve heat plant resiliency. A new fuel oil generator and belly tank could be installed outside the plant.

5.2.6 Heat Plant Electrical Modifications

The main 1600 amp service switchboard in the basement would remain, along with the associated emergency transfer switch. Existing sub panels around the plant would also remain in service.

Panel M on the main level is in good condition and would remain in service. Panels P and PA require immediate maintenance, including wipe-down cleaning inside and out, new screws to secure the dead-front panels to the enclosure, and verification that the dead-front over the breakers fits securely with no spaces around the breaker and no spaces between the dead-front covers and the enclosure box. These three switchboards could remain in service for an additional 5 to 10 years, then replacement with new equipment should be considered.

The MCC on the main level is obsolete and much of it is abandoned. With the change to VFDs and electronic controls already taking place, there is a need to revise the current configuration to more useful switchboard and accessory equipment. It is recommended the MCC be replaced with a 600 amp switchboard to handle new larger motors and heavier load, and also support a new 200 amp sub-panel for smaller 120 volt loads. This smaller panel is suggested to be protected with a surge protective device and possibly have a UPS connected for controls power backup. The UPS could back up the entire panel, or could be connected to a large circuit from the panel and distribute power as secondary receptacles to specific control cabinets and computers.

With the possible relocation of the control room and new more modern boiler equipment suggested, power system protection and monitoring should be considered such as sub-metering and and cascaded surge protective devices. Sub-metering can be very helpful for tracking power capacity in the panels when adding new accessories, and would help track power quality problems that affect sensitive controls. Cascaded surge protection systems apply different surge protection features to different levels of the system. The service switchboard would be protected with a service entrance rated unit for transients from lightning or utility switching events, while sub-panel units would be better tuned to suppress surges from starting motors, capacitors, and other switching events to better protect smaller electronic loads. These accessory units are more cost effective when purchased with new panels and switchboards.

5.3 Modifications to Campus Distribution

The existing steam distribution would remain. The utility tunnels that house the existing steam distribution piping, and other utilities, should continue to be maintained and reinforced per the 2018 tunnel survey project recommendations. Maintaining the tunnels is an ongoing cost, but since portions of the tunnels house more utilities than just the steam distribution piping those portions of the tunnels would still need to be maintained or those utilities relocated. The costs to maintain the tunnels are still much lower lower than constructing a new heating distribution system.

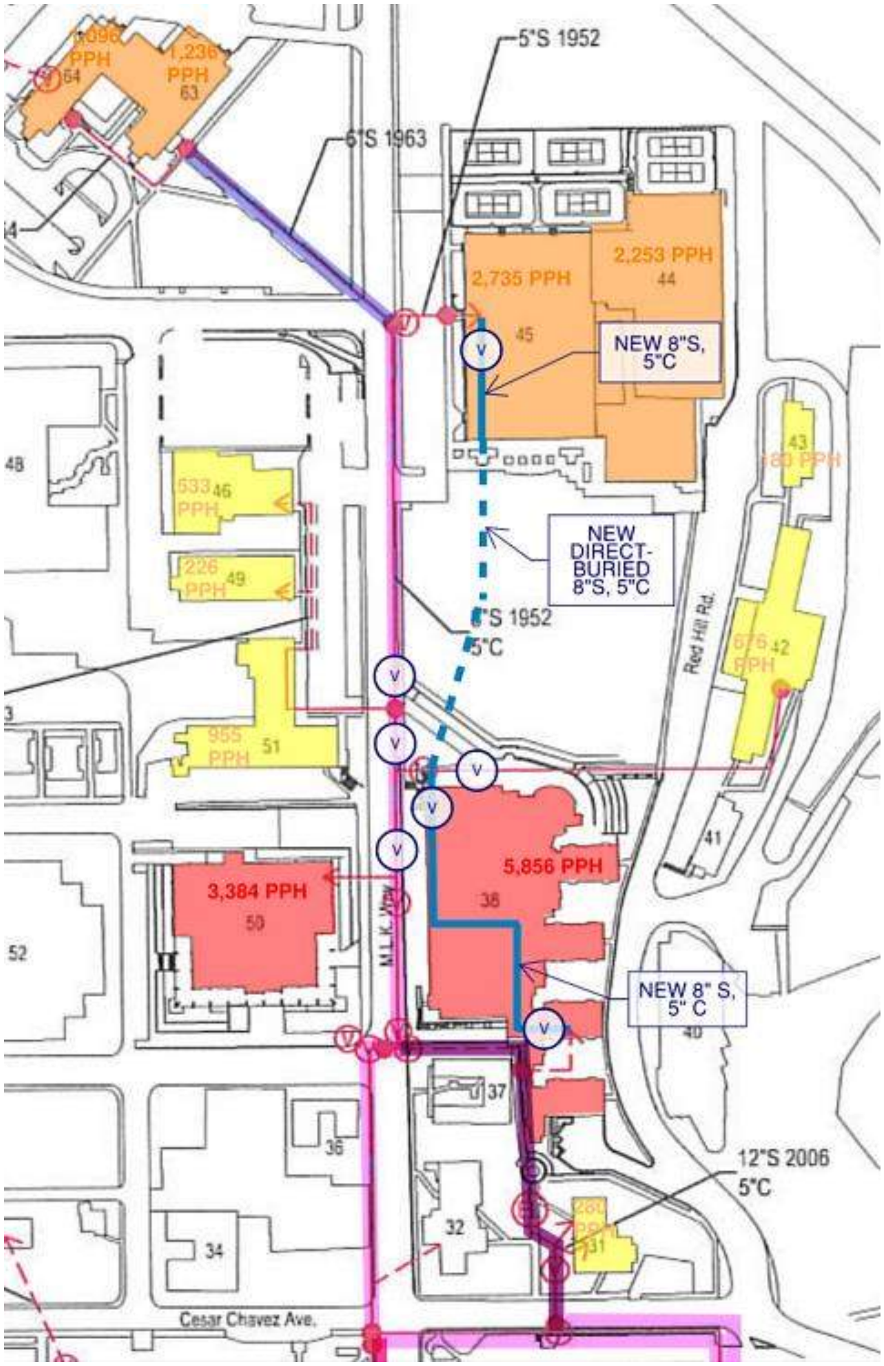
5.3.1 Completion of East Campus Steam Loop

As discussed in Section 3.6, the steam distribution system currently lacks complete redundancy for the east section of campus that is fed from the one main pipe from the Library and Rendezvous to the east along Martin Luther King Jr. Way. This pipe is a single point of failure that would cause a heating outage for the east campus creating significant operational disruption as well as potential damage to buildings due to burst pipes if heating is not restored quickly. To address this at least part of this vulnerability, a campus steam loop should be completed on the east side of campus. Several routes were considered for the loop. Descriptions of the different alternatives can be found in Section 6 of this report.

The recommended solution would be to route a new 8-inch steam and 5-inch condensate pipe through the basement of Reed Gymnasium from the current steam main tie-in toward the west side of the building. These pipe sizes match the size and capacity of the existing main pipes in the tunnel along Martin Luther King Jr. Way that currently feeds east campus. Once the new steam and condensate piping exits the basement of Reed Gymnasium, the new piping would then be direct buried across Cadet Field toward Rendezvous where it would tie-in at the existing steam vault in the northeast corner of that building. New 8-inch steam and 5-inch condensate pipes would then be routed from the vault through the basement of Rendezvous to the existing southwest loop tie-in off the 12-inch steam and 5-inch condensate lines. New main line isolation valves would also need to be installed in several locations along the east campus route in order to benefit from the redundancy of the newly completed east campus distribution loop. These locations are identified on the map shown on the following page.

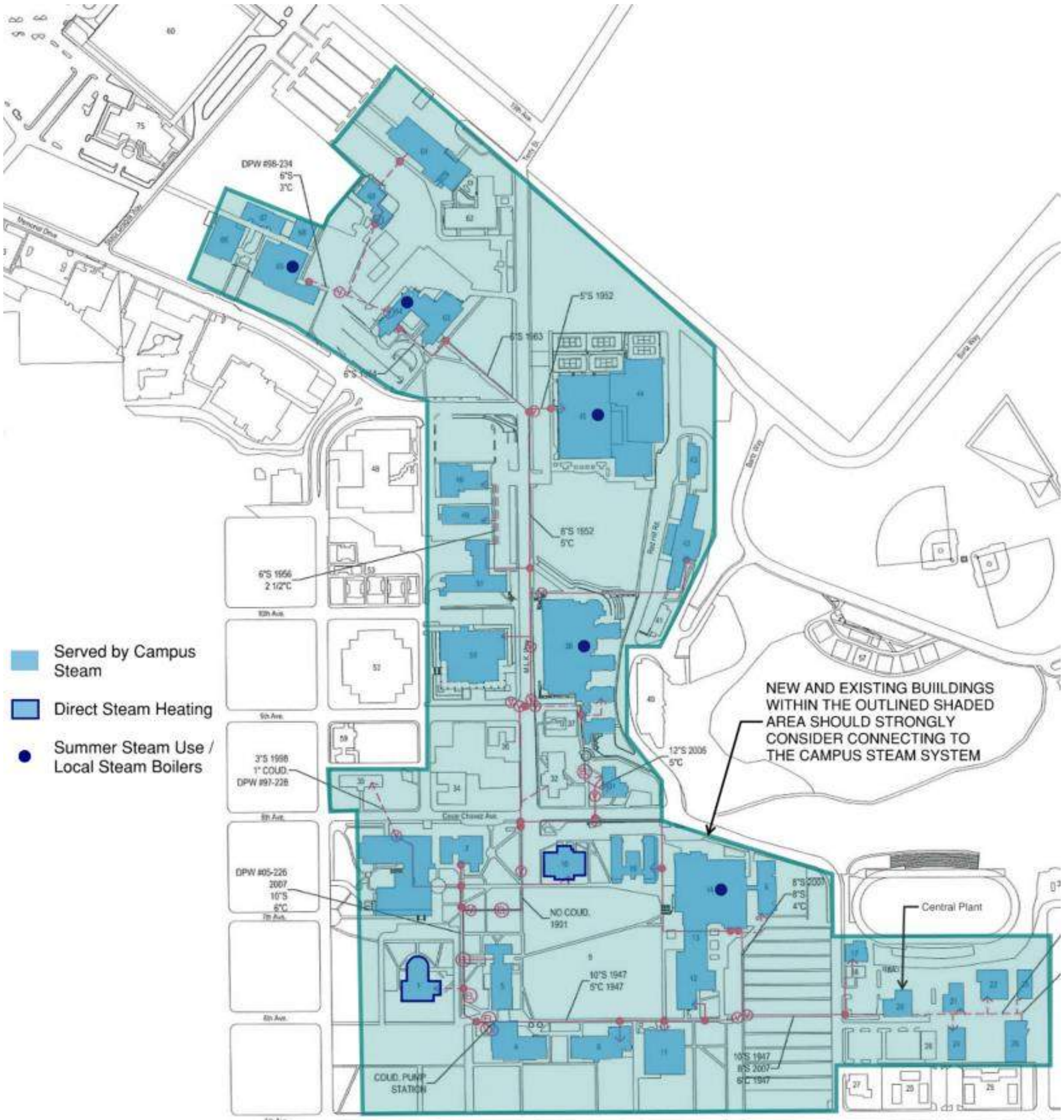
This work would enable Reed Gymnasium, the Student Recreation Facility, the Owen Redfield Complex, Dyer Hall, Vocational Arts, Industrial Crafts (ESTEC) Trade & Technology and the Eli Oboler Library to be served from a loop instead of a single main line.

The buildings at the far east of campus would still have a single point of connection to the main steam system. Those buildings would include Albion Hall, Garrison Hall, Turner House, Gale Life Science, Beckley Nursing, the Lecture Center, Speech Pathology/Audiology, and Plant Sciences. However, most of these buildings do not have large steam loads, and the buildings with special critical steam uses, Gale Life Science and Turner House, have their own secondary steam boilers to cover those loads. Therefore, the benefits of completing the loop to those buildings would most likely not outweigh the costs associated with the large amount of direct-buried piping that would be required or outweigh the traffic disruptions and potential right of way issues that would need to be navigated in order to bury new piping across the main campus thoroughfares, Memorial Drive and E. Terry Street.



5.3.2 Guidelines for connecting future buildings to the steam loop

All buildings currently served by the campus steam loop should remain on the steam system at least until programmed for a full renovation. Furthermore, new or existing facilities directly adjacent to the main steam distribution loop on Martin Luther King Jr. Way and in the Quad should strongly either connect to the central steam system or, if the design parameters allow, use independent fully electric heating systems. New buildings within the envelope described on the next page should not be constructed with individual fuel fired boilers but should connect to the steam heating loop through centralized steam to hot water heat exchangers. All new buildings using heating water should use design temperatures of no more than 140°F for future source flexibility. Buildings that are farther from the main steam piping should have separate heating systems since connecting to the campus steam would require significant lengths of buried steam and condensate piping and would be less cost effective than installing stand-alone heating systems.



5.3.3 Recommendations for Existing Campus Building Renovations

Since the campus would stay on a steam system, no modifications to existing buildings would be required as part of the scope of this Master Plan. Converting buildings from steam to hot water heating does provide tighter temperature control for occupant comfort but these renovations should be made based on each individual building's needs. They would be neither required nor prohibited by the recommended heat plant Master Plan.

5.4 Summary of Project Scopes and Budgets

The following project, identified as Phase 1 of the Master Plan, is critical to campus heating resiliency and should be completed as soon as possible. **Note that all costs in this section are in 2021 Dollars and must be escalated according to material and local labor inflation to the midpoint of any potential project.**

Phase 1 – Installation of new large industrial boiler at the existing plant

Included in the scope of work:

- Removal of Boilers #1 and #2 (including asbestos abatement)
- Removal of existing Boiler #1 and #2 stack and baghouse
- Removal of existing coal silo, coal hoppers, coal conveyers and ash hoppers
- Interior seismic bracing of original plant
- Purchase and installation of 50,000 pph boiler, including economizer
- Installation of new boiler stack
- Seismic anchoring of the new boiler
- Piping for new boiler
- Seismic bracing of new boiler piping and new steam header
- Piping up to isolation valves for future second boiler installation
- Connection of new boiler to plant PLC system
- Purchase and installation of new 5,000-gallon fuel oil system for boiler back-up fuel
- Purchase and installation of duplex compressed air system for boiler fuel oil atomizing
- Purchase and installation of second condensate receiver
- Addition of new office and break room spaces in original plant
- Seismic bracing of existing feedwater equipment and piping, including deaerator and condensate receivers
- Remove motor control center, MCC, and abandoned conduit and wire to older coal support equipment.
- Install a new 480Y/277 volt, 600 amp panel, new transformer and 208Y/120 volt panel for new boiler loads. The new 480 volt panel will be fed by the existing MCC feeder circuit out of Panel M.
- Clean and perform maintenance on Panels M, P, and PA. Verify dead-front is properly secured on each panel.
- Perform an available fault current study and arc flash study and apply proper labeling with the results on all equipment rated 200 amps and above.
- Install new coordinated surge protective devices on service panel and new MCC replacement panels.
- Install customer owned metering on main service and new panels to monitor power quality and load trending.

The opinion of probable cost for this project is **$6,650,000**, which includes both construction and design fees. Project costs for ISU construction management, bid advertisement and evaluation, owner representatives, or other ISU direct costs are not included.

If the University determines a need for a larger boiler to accommodate future steam system growth, which is currently unanticipated at the writing of this masterplan, a 60 Mlb/hr boiler could be installed in lieu of the 50 Mlb/hr with an approximate project cost increase of **$574,000.** The larger boiler could be installed in the same location as the 50 Mlb/hr boiler but would result in a decrease of available space for the break room and office.

The following recommended Phase 2 projects have individual timelines identified. The order the projects are listed in under Phase 2 is not reflective of the order in which they should be completed. They are broken out separately, as they do not have common areas of scope and can therefore be funded and constructed individually.

Phase 2a –Completion of East Campus Steam Distribution Loop

This project should be completed in a 0–10-year time frame. Portions of the work could be combined with other tunnel projects if the area of work overlaps. This project could also be delayed until the critical tunnel upgrades identified in the 2018 tunnel study have been completed.

Included in the scope of work:

- Route 8” steam and 5” condensate pipes through the basement of Reed Gymnasium
- Direct-bury 8” steam and 5” condensate pipes across Cadet Field to existing steam vault near the northeast corner of Rendezvous
- Landscaping re-work for portion of Cadet Field along new piping route
- Route 8” steam and 5” condensate pipes through the basement of Rendezvous

Install new isolation valves in existing east campus main line steam and condensate piping The opinion of probable cost for this project is **$2,220,000** which includes both construction and design fees. Project costs for ISU construction management, bid advertisement and evaluation, owner representatives, or other ISU direct costs are not included.

Phase 2b –Installation of second large industrial boiler at existing plant

The following project should be completed in a 5–10-year time frame.

Included in the scope of work:

- Purchase and installation of 50,000 pph boiler, including economizer
- Installation of new boiler stack
- Seismic bracing of new boiler
- Piping connections to capped and valved lines installed in first boiler project
- Removal of Boiler #3 (including asbestos abatement)
- Relocation of control room and restroom to Boiler #3 bay
- Upgrade of plant PLC system

- Connection to new plant controls system
- Replace Panels P and PA with new similar size and rating panels.
- Update the available fault current and arc flash studies and revise equipment labels as necessary.
- Install coordinated surge protective devices to replacement Panels P and PA.
- Add customer metering to the new panels for power quality monitoring and continuous load trending.

The opinion of probable cost for this project is **$3,560,000**, which includes both construction and design fees. Project costs for ISU construction management, bid advertisement and evaluation, owner representatives, or other ISU direct costs are not included.

Additional Potential Future Project – Seismic Upgrade of Original Heat Plant Building Envelope

If a detailed structural design determines that the seismic upgrade to the skin of the original plant can be delayed, then a separate project for the building exterior could be completed. This project could be completed at any time in the future as the University looks at other seismic retrofits and considerations for the rest of the campus. The cost for this work is difficult to determine at this time as variables in the existing building construction impact the design approach and potential solutions. Testing for existing re-enforcing and structural analysis are required before an estimate can be made.

5.5 Consideration of long term risk – Carbon emissions

Although investing in the current steam plant and infrastructure appears to be the best path for the university at this time it is worth discussing one potential long term risk of this approach. Many universities across the country have been promising and working towards drastic reductions in their carbon emissions footprint. This movement is driven by factors such as public image, activism in the student body, and local regulations and incentives that are not strongly present at ISU at this time. It is also possible that carbon reduction will drastically change the economic or legal landscape. A government mandate, tax, or penalties may make the continued use of fossil fuels much more expensive. It is likely that over the next 40 to 50 years there will be significant changes in the use, costs, regulation, and perceptions of fossil fuels. While choosing to invest in a steam based central plant and distribution system narrows the options for de-carbonizing this portion of the campus energy use there are some potential solutions that could still be employed. Significant changes in technology, economics, or utility infrastructure and usage would be required to economically implement any of these solutions, which is why they were considered but not recommended as part of the base master plan options at this time.

5.5.1 Options for Decarbonized operations

Option 1: Renewable natural gas: Some chemical and biological process produce methane that can be captured, cleaned, transported, and used as pipeline gas. This would allow the plant to operate with low emissions on the current and proposed boilers, without any equipment modifications. Such processes include anerobic digestion of animal or human waste streams (such as in wastewater treatment plants). In many cases gas from these sources could be considered carbon neutral. Gas from these sources is currently produced only in very small quantities and is very expensive compared to fossil gas. It is unlikely that renewable gas production can replace more than a small percentage of the current gas usage but by paying a significant premium the university may be able to reduce carbon emissions by using renewable gas.

Option 2: Electric boilers: Another possibility for operating a steam system with low to no carbon emissions would be a to use an electric steam boiler consuming electricity from renewable energy sources. Given the hydro power and wind power in the region sourcing emission free electricity should be attainable, however the electrical infrastructure at the heat plant would need a major upgrade. An electric boiler the size of the one proposed in phase 1 in the proposed master plan would require around 15 MW of electrical power at peak output. The most feasible option would likely be to bring a medium voltage (5-25 kV class) service from the nearest substation with sufficient capacity, and then install medium voltage switchgear at the plant. The electric boilers themselves are compact and around half as expensive, so an electric phase 2A could install two of these boilers (for redundancy) for around the same cost as the proposed 2A but then additional cost, in the millions of dollars would need to be added for electrical infrastructure upgrades. Finally the cost of operating the boilers would be much higher than operating gas boilers at current utility rates, so addressing the electrical rate structure with the utility would be a key consideration. .

Option 3: Carbon capture: It is technically feasible to capture the carbon dioxide from the exhaust gases of the boilers. Current technology would use thermal separation (cooling the flue gasses to the point where the CO_2 condenses), or chemical absorption (absorbing CO_2 in a chemical reaction and then releasing it into a contained space in a second reaction). Both options involve a considerable amount of equipment, cost, and electrical energy in addition to a place to sequester the carbon dioxide.

Option 4: High lift heat pump: This option would require development of new heat pump technology capable of producing steam at the pressures required by the University's distribution system. The temperature of fluid that a heat pump can produce is limited by the refrigerant used and the pressure developed by the compressor. Commercial, large capacity, heat pumps can produce 140 degree water easily, and newer versions are pushing to higher temperatures but only small scale experimental or niche heat pumps exist that can generate even low pressure steam. If, however, a multistage or very high lift (lift is the difference in temperature between the heat pump's heat source and the heated fluid) commercial unit were developed it could be applied at ISU. The final piece of the puzzle needed to operate a heat pump system would be the heat source. Ideally this would be something warmer than the ambient air temperature on the coldest days, such as a geo-exchange system, or other higher heat source. The solution would require additional equipment both inside and outside the plant as well as a new electrical service as the heat pumps would require approximately 5 MW of electrical power at peak output. The utility costs to operate they system would be close to parity with a gas system under current rates.

Option 5: Minimize steam use then combine with one of the other options listed here: Another option is to renovate buildings for energy efficiency and to reduce each buildings steam use before initiating one of the other options listed here. Air or water source heat pumps could pe installed during building renovations, heat recovery air handlers, better insulated windows, and building weatherization efforts could all reduce steam consumption. For buildings other than laboratories or other high ventilation spaces current heat pumps on a condenser loop heated by steam as necessary provides a very efficient system.

Option 6: Combination of Option 1, Option 5 and Combined Heat and Power (CHP): This option would minimize steam use as described in Option 5, and use renewable fuels as in Option 1 but instead of using boilers for the now lower capacity steam system it would use a microturbine or other CHP unit that would produce steam and also electricity to maximize the energy available in the renewable fuels.

6. Master Plan Alternatives Considered

Prior to selecting the path for the Master Plan, the team considered many different heating alternatives for the campus. These alternatives are described below. The order in which they are listed does not indicate a preference for one alternative over another.

6.1 Considered Alternative #1: Invest in Steam – Current Plant

This alternative is the selected path for the Master Plan that is presented in Section 5. However, several different variations for investing in steam at the current plant were evaluated and are detailed below.

6.1.1 Alternative 1A – Add vertical steam boilers to existing plant

This option would expand the steam capacity of the central plant by adding light vertical steam boilers (sometimes called steam generators), each with a capacity of about 10,000 lbs/hr. All units would be dual fuel and could be a continuation of the project discussed in the immediate needs report. The first two boilers would provide enough capacity to back up Boiler #4 with the new boilers plus Boiler #3. Installing the second two boilers would provide redundancy to Boiler #4 without relying on either old Boiler #2 or Boiler #3. Installing the second two boilers would require the removal of Boiler #1, which contains asbestos and will be costly to remove. All four new boilers would be dual fuel, and a fuel tank would be installed as part of this alternative if not already installed. In addition, two of these boilers could satisfy campus steam demand on their own for a little better than half the heating season and with integral economizers would be as efficient or more efficient than Boiler #4. Finally, light boilers provide good turndown capability to match steam production with campus steam demand and would allow for summer operation if desired.

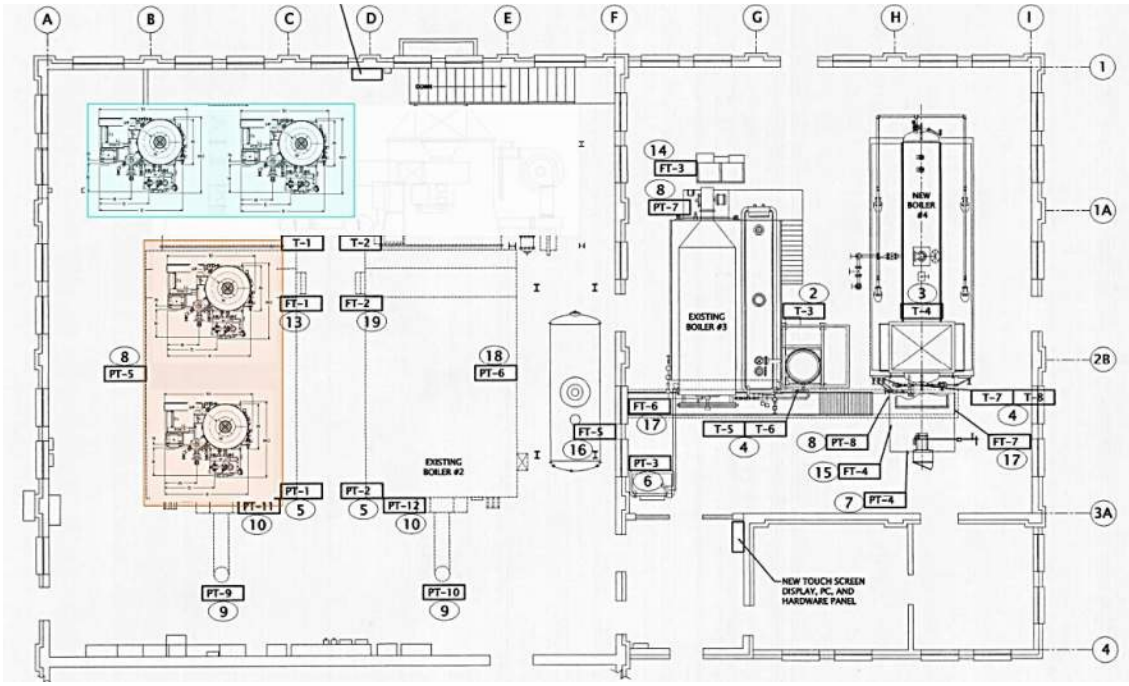


Figure 6.1.1 – Plan for Alternative 1A

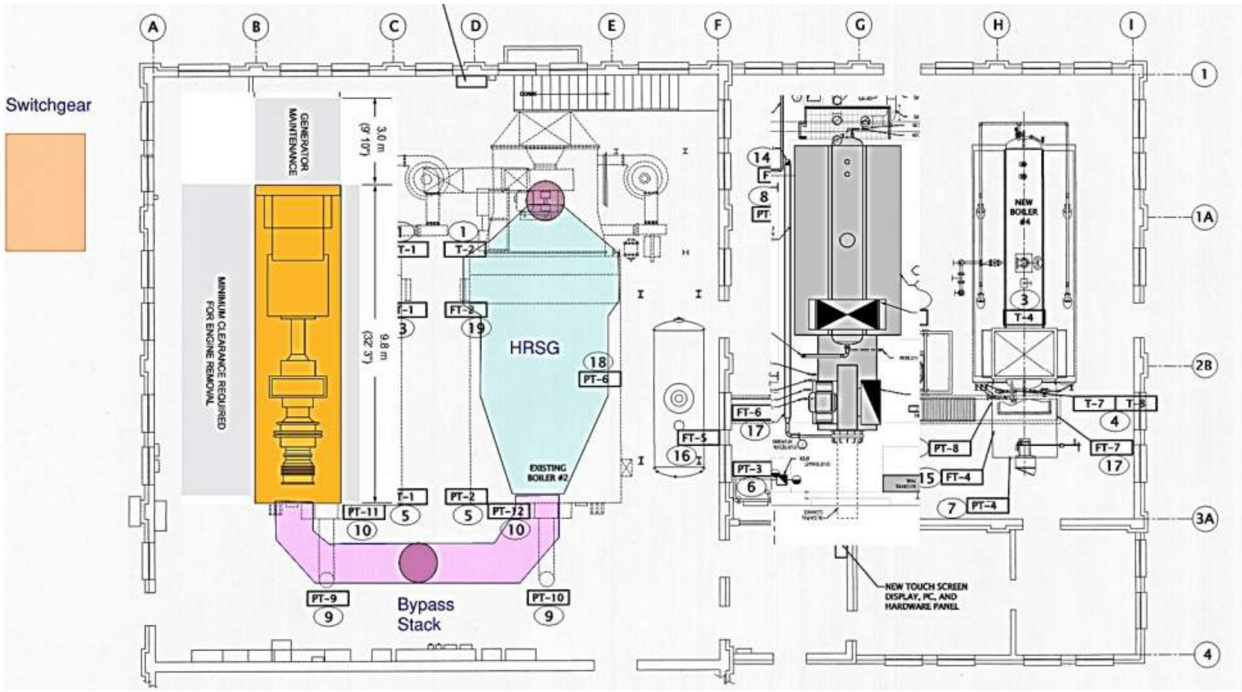
6.1.1 Alternative 1B – Add industrial boilers to existing plant – Chosen Alternative

This alternative was chosen as the basis for the Master Plan detailed in Section 5.

6.1.1 Alternative 1C – Add cogeneration to existing plant

This alternative would introduce combined heat and power to the campus. Boilers #1 and #2 would be removed and a Centaur 40 combustion turbine driving a 3.5-megawatt electrical generator would be installed. Turbine exhaust would be routed through a heat recovery steam generator (HRSG). The HRSG would produce steam directly from the hot turbine exhaust gases and would also be fitted with a duct burner to increase the steam output. Producing additional steam through a duct burner is nearly 100% efficient since that portion of the steam production comes from overheating the already very hot flue gases and still brining the exhaust temperature down to typical boiler exhaust temperatures. Cogeneration systems can operate continuously and reliably if well maintained and connected to a stable electrical grid.

On the ISU campus, the electrical distribution between buildings is owned and operated by the electrical utility. Because the cogeneration system would generate far more power than is consumed in any one building, the utility would need to accept and distribute the power produced by the turbine. This would require a close partnership and agreements between the university and the utility. When considering this option, the ability to operate the cogeneration system depends on the ability to produce and export electrical power. If power export may be interrupted, additional boiler capacity should be considered. Boiler #3 would be removed, and an additional industrial 50 Mlb/hr boiler, or four of the smaller 10,000 lb/hr light vertical boilers could be installed to back-up Boiler #4 if and when the cogeneration system is offline. The new boiler and cogeneration system would both be dual fuel and a new fuel tank installed as part of this alternative.

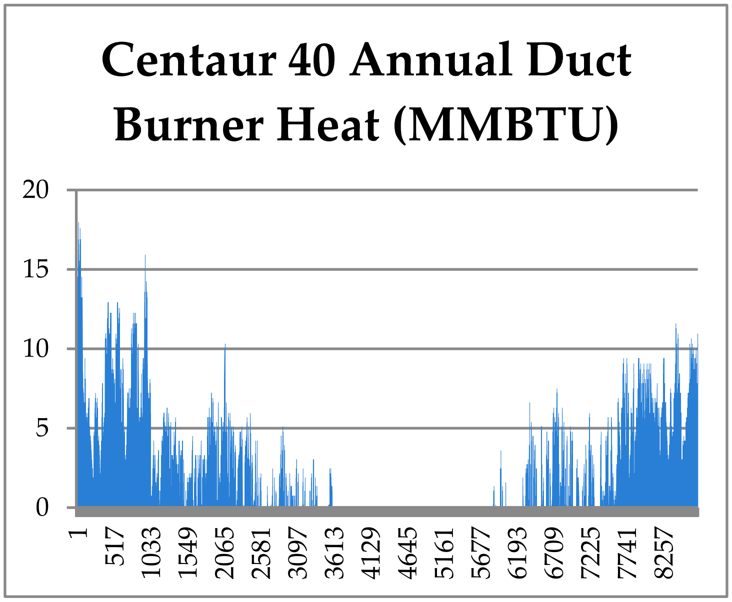


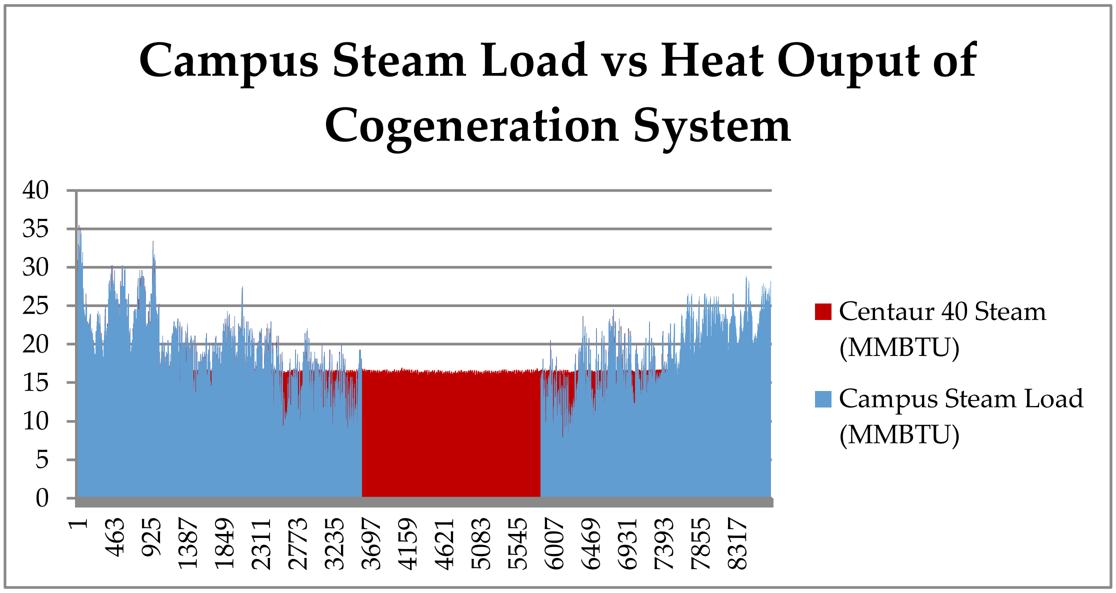
The installation shown above would provide N+2 redundancy to the campus. Boiler #4, the new industrial boiler and the HRSG, would each be able to cover the campus steam load individually. The cogeneration alternative would also produce steam approximately 30% more efficiently than boiler operation when electrical output is also considered. A low NOx package on the turbine can result in producing less NOx than the existing boilers. The NOx emissions could be significantly reduced by adding a selective catalyst reduction (SCR) section to the HRSG, but it is anticipated that this level of NOx reduction would not be required with an installation that is not in an air quality non-attainment zone.

A cogeneration system would require several additional elements that would add to construction investment costs:

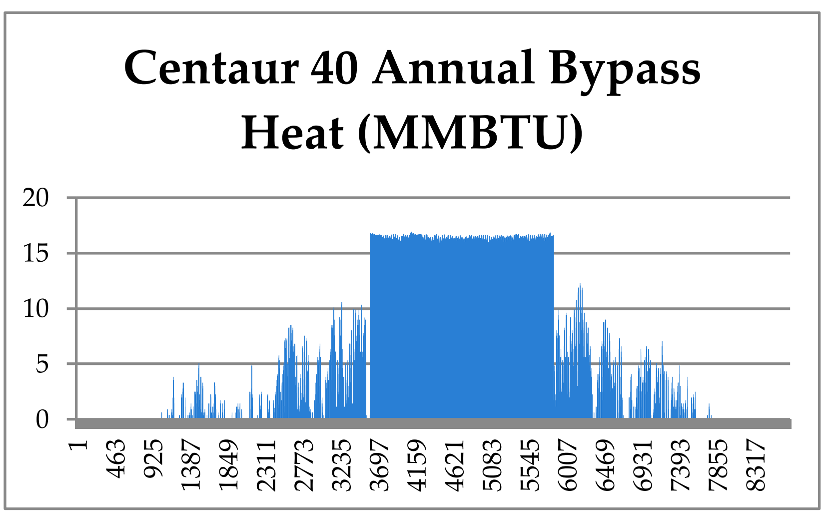
- Electrical switchgear, protective relaying and utility metering equipment
- Lube oil cooling system
- High pressure natural gas service or natural gas compressor
- Overturning structural restraints, typically a full length, 10-12-foot-deep concrete foundation and anchors
- Bypass stack to reduce steam production when steam production from the exhaust gases exceeds steam demand
- Special intake ductwork turbine and air inlet evaporative cooler
- Gaseous fire protection system for the turbine enclosure

The steam output of the cogeneration system and campus load for a typical year can be seen in the chart below. The red bars represent the HRSG output from the turbine gases only, this is the minimum output. The blue bars are the campus demand. When campus demand exceeds the minimum output, the system would fire the duct burner to match campus load, and when load dips below the minimum output, the bypass stack would open to exhaust some of the turbine exhaust gases upstream of the HRSG.

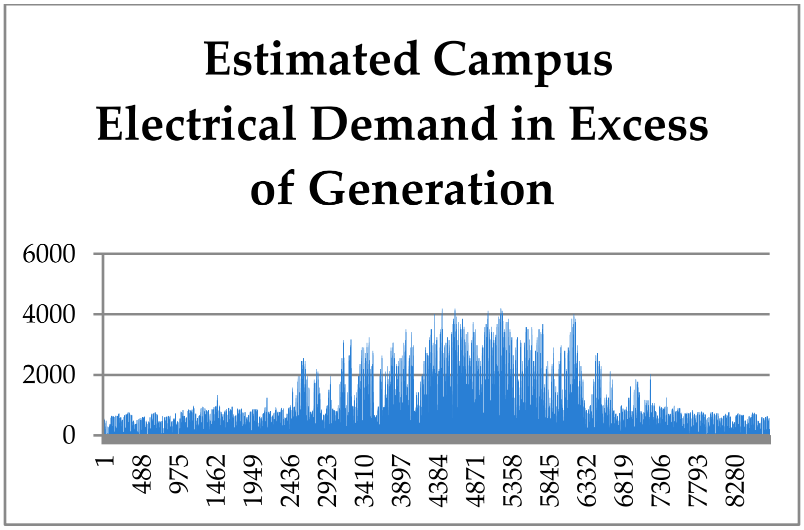




Note that in the chart above the campus summer steam plant load is zero since the steam plant is not currently operated during the summer. This results in significant bypass heat (see chart below). The local building steam boilers currently employed in the summer months have a combined output of 8,800 lbs/hr. However, the actual summer, end point, peak load is most likely 5,000 to 6,000 lbs/hr due to diversity and the average load is likely 2,500 lbs/hr or less. This load, plus about 2,000-3,000 lbs/hr to keep all the campus distribution lines warm, would represent the potential steam use during summer. Therefore, even if the campus steam system ran during the summer, the turbine would still generate significant bypass heat, about 10,000 MMBtu. This exhaust heat represents a significant waste and would depress the annual operating efficiency and negatively impact the economics of the cogeneration system. A steam turbine generator could be installed to consume the bypass heat and generate additional power with an added investment cost. The steam system could be run in the summer, keeping the summer boilers off but complicating steam line maintenance, and this would only result in partial use of the turbine exhaust heat. In any case the current summer operation represents a disadvantage and complication for the cogeneration system. .



The cogeneration system would satisfy a significant portion of the campus electrical demand but rarely would power production approach the total campus demand. The chart below shows the estimated electrical demand, after the power generated by the turbine.



On an overall campus basis, the fact there is not excess power generated by the Centaur 40 over the campus electrical demand, is good. Utility companies typically do not want excess power from third-party power producers.

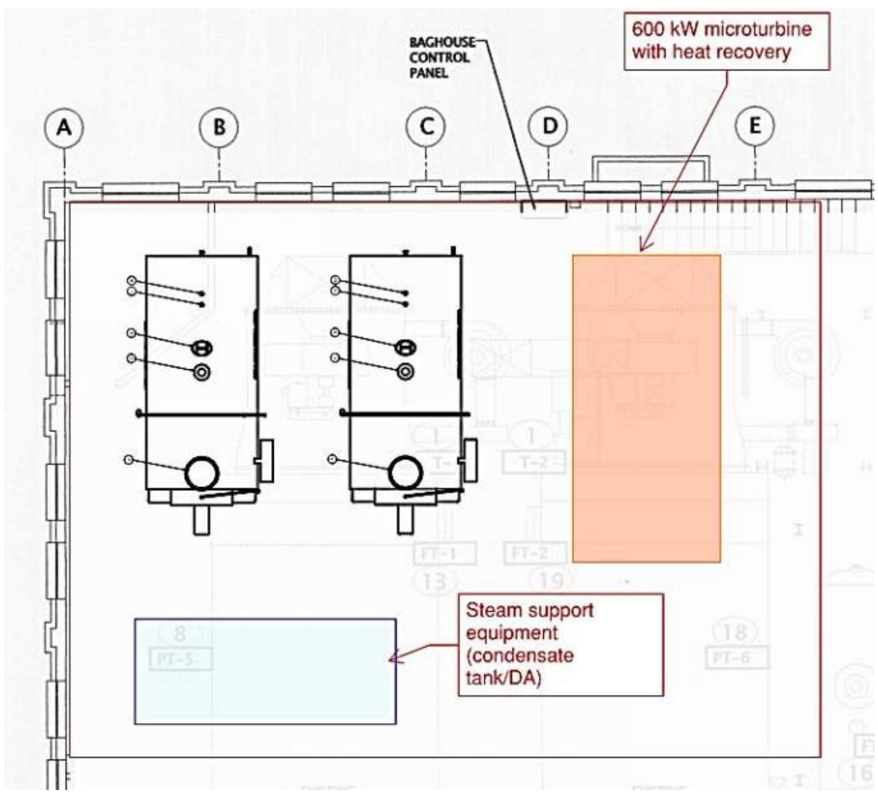
Since power is distributed to each of the buildings on campus by the electrical utility service (Idaho Power), the power produced by the turbine would need to be distributed via the utility power network on campus. Therefore, a cogeneration system would need to be fully coordinated with and endorsed by the utility. The interest level of the utility would most likely determine the financial viability of this alternative. In addition, since the power distribution network would be maintained by the utility, in the event of a utility power outage, the turbine would not be able to operate. Also, the University does not have the electrical switching to maintain generation during a widespread electrical power outage. One of the advantages of cogeneration systems for many campuses is the ability to “Island” maintaining electrical power during a utility outage. While it is possible to achieve, and perhaps in the campuses best interest, ISU’s electrical system is not capable of this without significant investment.

6.2 Considered Alternative #2: Invest in Steam – Auxiliary Plant

This alternative would also maintain steam as the heating medium for campus but would increase campus resiliency by installing a new seismically rated steam plant in a different location on campus. The new heating equipment would increase reliability and efficiency. As in Alternative 1, a liquid fuel system would provide on-site fuel storage to guard against an interruption in natural gas service and potentially allow a less expensive interruptible gas service. Liquid fuel storage would also be installed at the existing central plant to provide further campus redundancy. In addition, the existing heating distribution system would also be fortified and expanded upon to eliminate single points of failure. The auxiliary plant would ideally be located on the portion of campus not currently served by the steam loop, so that the auxiliary plant construction could include completing an east campus steam distribution loop to address this vulnerability in the current distribution. The advantages of the auxiliary plant alternative are the resilience of having a second plant, the seismic construction, the addition of redundant steam distribution to east campus, and the construction of a new plant would not interfere with current plant operations. As with Alternative 1, outside of the auxiliary plant, no building retrofits or changes would be required.

This alternative would consist of installing two light vertical steam boilers, or two heavy duty commercial horizontal fire tube boilers each with a capacity of 10,000 lbs/hr. These boilers would provide enough capacity to back up Boiler #4 with the new boilers plus Boiler #3. In addition, these boilers could satisfy campus steam demand on their own for a little better than half the heating season and with integral economizers would be as efficient or more efficient than Boiler #4. Finally, these boilers would provide good turndown capability to match steam production with campus steam demand.

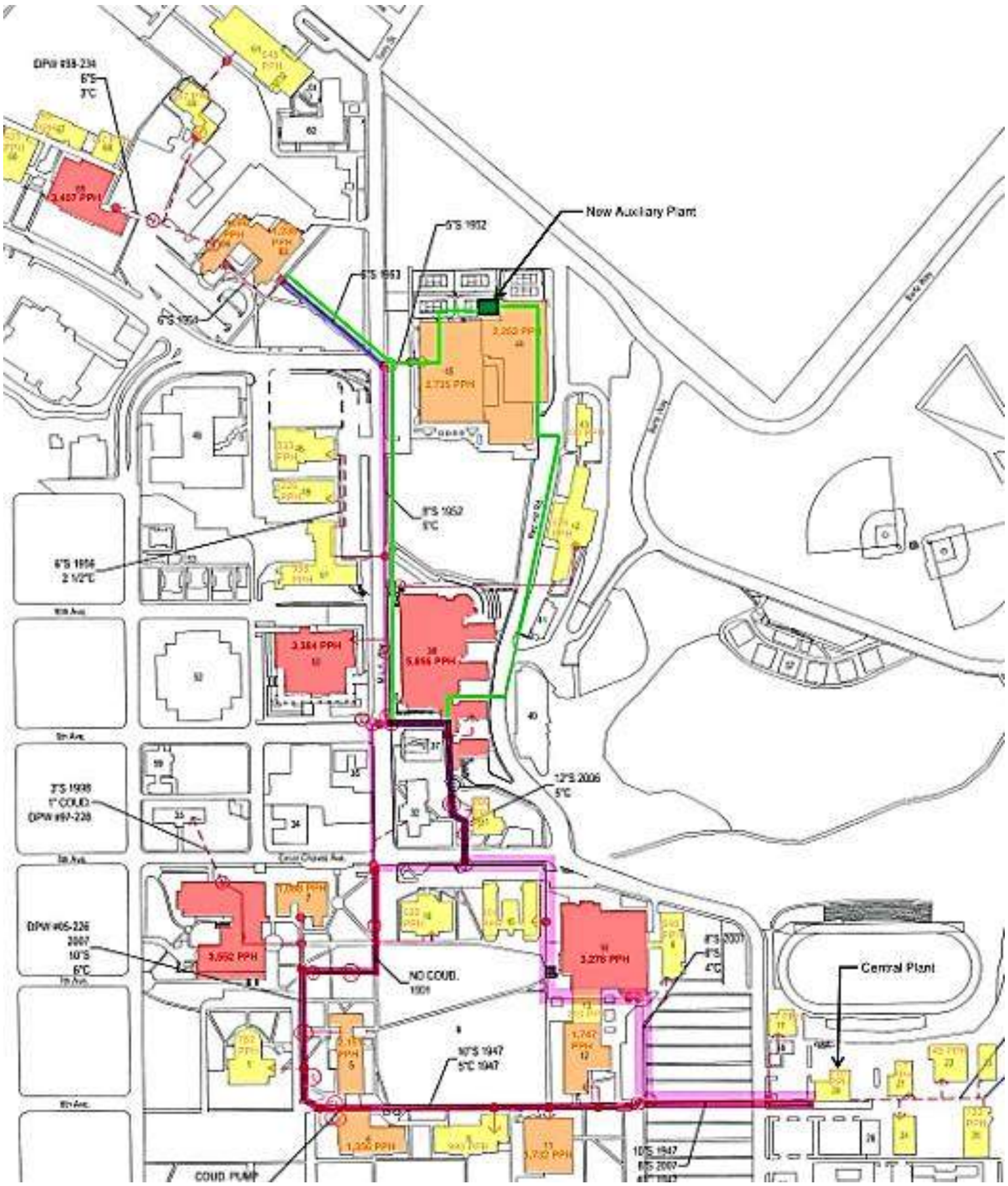
Installing two smaller boilers in lieu of a large industrial boiler would keep the size and cost of the new plant down. In addition, the capacity of the auxiliary plant is limited by the size of the steam main going back to south campus which is only an 8 inch. A third light boiler or a microturbine with heat recovery could be installed as back-up to the first two boilers. Steam support equipment such as a condensate tank and deaerator would also be installed at the auxiliary plant. A new natural gas service and electric power service would be required at the auxiliary plant location.



Some of the disadvantages of this alternative are that it would have higher initial investment costs due to the need to construct a new facility. The addition of an auxiliary plant would also complicate system maintenance by decentralizing the steam system. The added distribution piping to complete the steam loop on the east side of campus greatly increases campus resiliency but would have significant costs associated with it. Condensate from the western side of campus would have to be pumped up to this location if the main plant were not operating or the output from this plant exceeded the consumption of the east part of the campus. Therefore, a new condensate pump and piping back to the auxiliary plant are required at a location in a building or tunnel on the west side of campus. It should be noted that the steam loop on the east side of campus could be completed as part of Alternative #1 as well.

The auxiliary plant would ideally be located on the opposite side of campus as the current steam plant and should offer a pathway for completing the steam loop on the east side of campus. Three possible locations were identified. The locations and their associated proposed distribution piping are shown on the figures below.

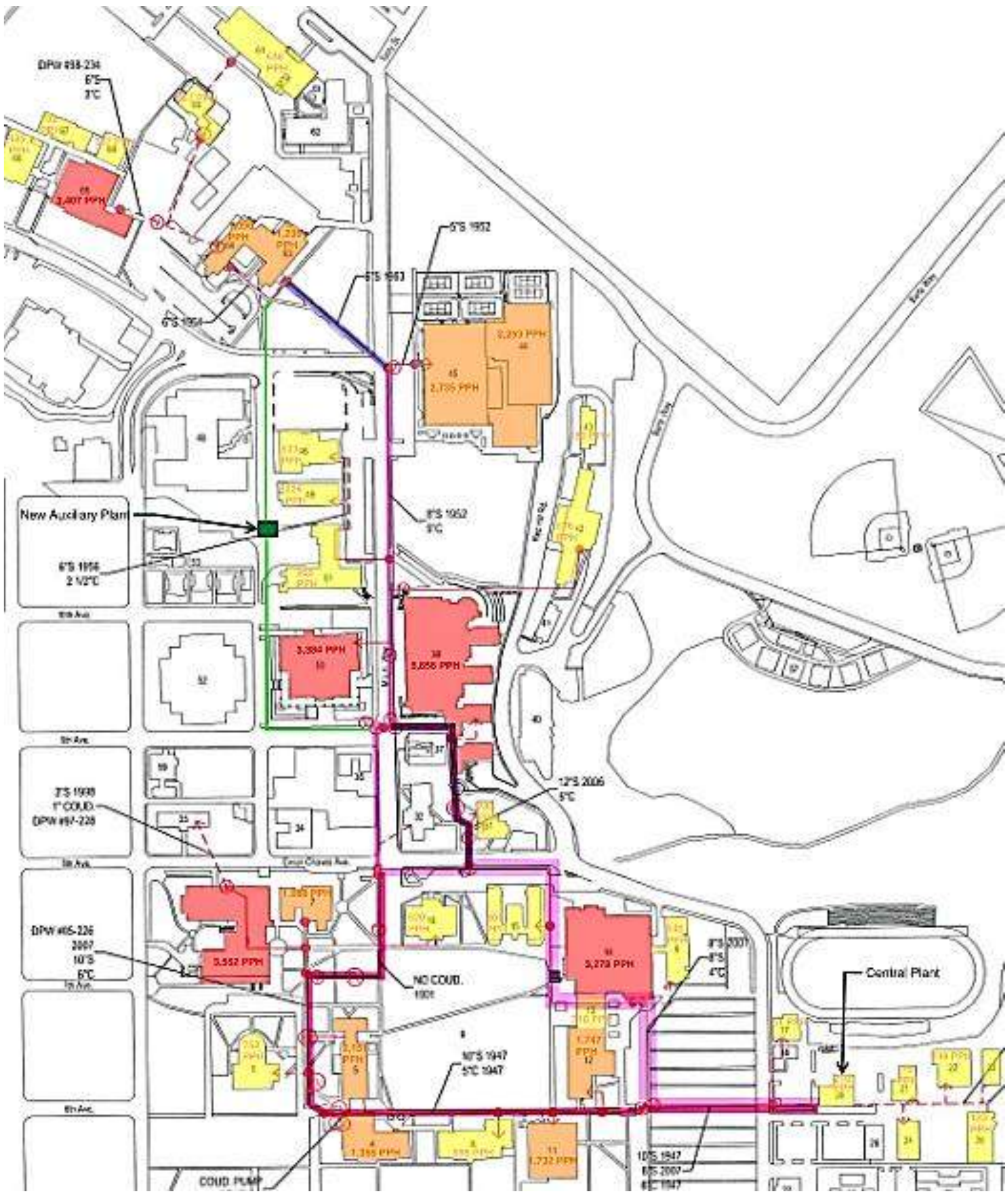
6.2.1 Alternative 2A – Auxiliary Plant at Reed Gym



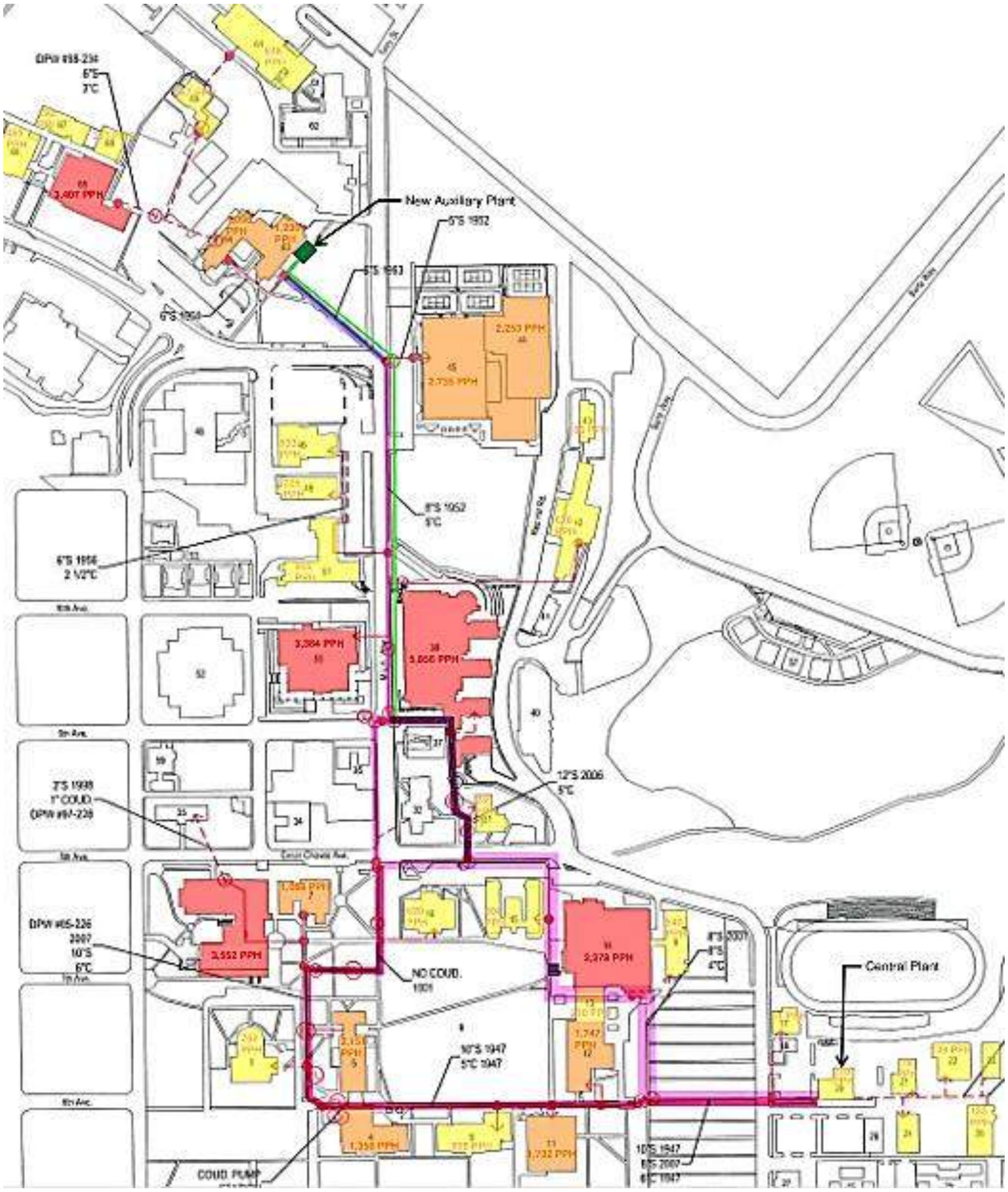
In this alternative, there are three distribution options. The new steam main could be routed along Red Hill Road and tied in at the Rendezvous building. The northeast end of campus (63,64,65, etc.) would still not be fed from a loop with this routing option. If space allows, the new steam main could be routed in the existing tunnel along Martin Luther King Jr. Drive in a similar manner to how the steam lines were added in the 2006/2007 project. If space allows, a second steam main could be added in the tunnel from Reed Gym over to the northeast buildings (63,64,65 etc.). The northeast part of campus would then be included on the loop.

6.2.2 Alternative 2B – Auxiliary Plant at Building 51

An advantage to this location and new distribution routing is that the far northeast buildings (63,64, 65, etc.) would now be fed from a loop.



6.2.3 Alternative 2C – Auxiliary Plant at Building 63



The new steam main would be routed in the existing tunnel along Martin Luther King Jr. Drive in a similar manner to how the steam lines were added in the 2006/2007 project. The northeast part of campus would then be included on the loop.

6.3 Considered Alternative #3: Distributed Heating Systems

This alternative would abandon the campus steam system and adopt a distributed heating system. More than 100 packaged water boilers ranging in size from 200 MBH to 3000 MBH would be installed at individual buildings. The new boilers would be installed in existing mechanical rooms, storage rooms, or new rooftop penthouses depending on each building's space availability. While most buildings have an existing natural gas service, the meter size would need to be increased in most cases and new services added to those buildings without natural gas.

This alternative would also include hot water conversion of most or all buildings using steam directly for heating as the increased cost of installing a steam plant would be more than renovating the building for hot water heating or even gas-fired unit heaters for shop, storage, or field house spaces. Another consideration would be the amount of redundancy required at each building. RMH usually recommends at least two boilers except for very small buildings (less than 500 MBH load). The table below lists the boilers equipment required to convert the campus.

Building Number	Building Name	Heat Load	Number of Boilers	Boiler Size	Notes
		MBH	#	MBH	
38	Rendevous (see housing be	5856.33	3.00	3000.00	Retain steam boiler
3	Physical Science - Complex	3552.06	3.00	1800.00	
65	Biology (Gale)	3407.35	3.00	1800.00	Retain steam boiler
50	Library - ELI M Oboler	3383.98	3.00	1700.00	
14	Student Union & Bookstore	3278.04	3.00	1700.00	
45	Reed Gymnasium	2734.89	2.00	1700.00	Retain steam boiler
44	Student Rec Center	2253.44	2.00	1400.00	
5	Business Administation	2150.81	2.00	1300.00	
12	Museum	1747.24	2.00	1100.00	
11	Fine Arts	1732.33	2.00	1100.00	
4	Liberal Arts - Kegel	1355.60	2.00	900.00	
63	Garrison Hall	1236.63	2.00	800.00	Remove steam boiler
64	Turner House	1095.61	2.00	700.00	DHW storage
7	Engineering - Lilibridge	1088.04	2.00	700.00	
8	Pharmacy - Leonard Hall	994.65	2.00	600.00	
51	Trade & Technology	955.47	2.00	600.00	
15	Graveley Hall	803.84	2.00	500.00	
1	Frazer Hall	751.55	2.00	500.00	
42	Owen Redfield Complex	675.52	2.00	500.00	
61	Albion Hall	647.45	2.00	400.00	
10	Administration	620.39	2.00	400.00	
6	Early Learning Center	540.41	2.00	400.00	
46	Vocational Arts	533.02	2.00	400.00	
66	Nursing - Beckley	484.65	1.00	500.00	
69	Plant Sciences	367.24	0.00	400.00	Unit Heaters
68	Speech Pathology - Audiolo	357.14	1.00	400.00	
31	Student Health Center	279.67	1.00	300.00	
49	Estec	225.99	1.00	300.00	
20	Heat Plant	210.03	0.00	300.00	Unit Heaters
13	Hypostle	200.36	1.00	300.00	
67	Lecture Center	192.33	1.00	200.00	
43	Dyer Hall	180.17	1.00	200.00	
22	Ships	149.27	0.00	200.00	Unit Heaters
26	Shipping and Receiving - sh	133.12	0.00	200.00	Unit Heaters
21	Transportation services sho	78.64	0.00	100.00	Unit Heaters
17	Davis Field House	50.60	0.00	100.00	Unit Heaters
38	Rendevous (see above)	0.00	0.00	0.00	
23	Bengal Depot	0.00	0.00	0.00	Unit Heaters
24	Custodial/Welding	0.00	0.00	0.00	Unit Heaters
			113.00		

The advantages of this alternative are that the aging steam distribution system could be abandoned. No campus heating distribution system would need to be maintained since the natural gas distribution required for this alternative would be managed and maintained by the utility. In addition, the hot water boilers are more efficient (84%-99%) than the existing steam boilers (79%) and can be fitted with low NOx burners. Buildings with low heating water supply temperatures would be on the high end of the efficiency range and buildings with high heating water supply temperatures (~180°) would be on the lower end.

The disadvantages of a distributed heating system are that the individual buildings plants would not be dual fuel, and the alternative has a high overall footprint and a high impact on each building. Furthermore, a distributed heating system naturally has more individual pieces of equipment than a centralized heating system. The larger number increases the number of failures, and although each failure would be less expensive to repair than a failure in a large central boiler, overall maintenance costs would likely increase. This alternative would also require more scheduled and preventative equipment maintenance than a centralized system. In addition this option would not, by itself, allow the university to abandon the entire tunnel system. Many of the tunnels convey other utilities that would have to be moved in order to abandon the tunnels.

6.4 Considered Alternative #4: Incremental Hot Water Conversion

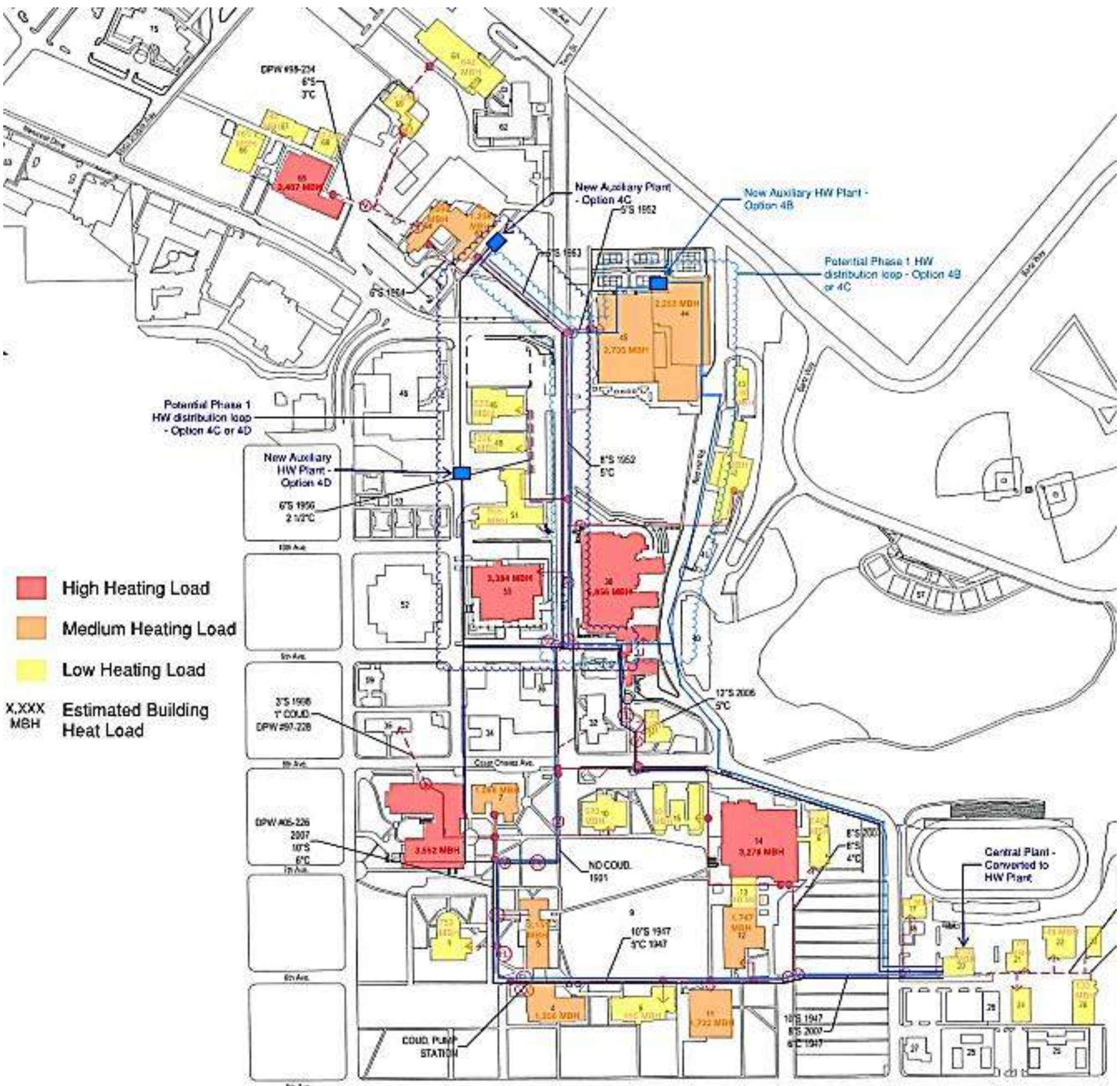
In this alternative, the existing steam system would be maintained while building a new heating water plant and distribution system that would be scaled up over time. The new heating water boilers would be more efficient (84%-88%) than the existing steam boilers (79%) and could be fitted with low NOx burners reducing emissions further. The efficiency of the new boilers depends on the heating water supply temperature required, with higher temperatures having lower boiler efficiency. The new boilers would be dual fuel to increase campus resiliency just as in Alternatives #1 and #2. New buried heating water supply and return mains would be installed with valve vaults at each building and main junction. The buildings that still utilize direct steam heating would need to be converted to heating water. Fortunately, there are not many buildings using direct steam heating. The buildings that require steam for other purposes (dishwashing, autoclaves, etc.) already have steam generators installed for summer operation and therefore would not require any modifications.

The primary advantages of this alternative are that campus would have new heating infrastructure, be more efficient, have lower emissions than with steam, and look forward to lower maintenance costs and equipment replacement costs in the future. The heating water piping is expected to be easier to maintain than the steam and condensate mains because treated heating water is less corrosive than steam condensate. However, this is not always the case, as groundwater can damage piping from the outside if it penetrates the outer conduit. Most failures in buried piping newer than 50 years old appear to be caused by external rather than internal factors.

Heating water is expected to be more flexible in the future than steam. The lower delivery temperature makes it more likely that other heating technology such as heat pumps can be applied in the future. Furthermore, an incremental conversion would have less upfront investment costs and an incremental conversion would give the University the opportunity to evaluate future heating technologies down the line and modify the remainder of the conversion accordingly. For instance, many of the campus heat pump conversions also have boilers for peak load and backup scenarios and boilers added in the first phases of a hot water conversion could be used in such a hybrid system. The incremental approach allows the University to schedule the necessary conversions of buildings using steam for direct heating to coincide with other renovation work, potentially capitalizing on synergies and efficiencies.

The disadvantages of converting to a hot water system from steam incrementally is that the overall cost would be higher, as individual projects would not benefit from the economy of scale that a single larger project converting the entire campus would have, and the steam system would have to be maintained longer. This results in much higher total cost than investing in the steam system with Alternatives #1 or #2.

An incremental hot water conversion could be implemented with several different strategies. Note that direct buried piping is shown to connect the campus buildings. This is because direct buried piping is more feasible for hot water than for steam and because the existing tunnels cannot accommodate hot water piping alongside active steam piping, or in some cases the tunnels are too small for the larger hot water piping even if the steam piping were to be removed.



6.4.1 Alternative 4A – Phased Central Plant Conversion

The first option would be to do a phased conversion of the existing steam plant. The first phase would involve removing Boilers #1 and/or #2 and installing hot water boilers in their place. Two large industrial boilers or several smaller packaged commercial boilers could be installed. Eventually steam Boilers #3 and #4 would be removed and replaced with hot water boilers. The southern heating water distribution loop would be completed in Phase 1, and the northern heating water distribution loop completed in the later phases. The advantage of this alternative is that a new facility would not need to be built to house the heating water boilers. In addition, maintenance would remain centralized. The disadvantage of this alternative is that the steam plant is far away from the north and east parts of campus that would remain on the steam system. This would involve maintaining the entirety of the steam distribution system and would still leave east campus vulnerable to a single point failure in its leg of the steam distribution system.

6.4.2 Alternative 4B – New Auxiliary Heating Water Plant at Reed Gym

In this alternative, a new auxiliary heating water plant would be built at Reed Gym, one of the same locations proposed for a steam auxiliary plant in Alternative #2. The new plant could either be scaled up over time to eventually carry the entire campus heating water load or part of the existing steam plant could be converted to a hot water plant in a later phase instead. The new Reed Gym heating water plant would have seismic construction.

A northern heating water distribution loop would be completed in Phase 1 with a southern loop added in a later phase. A portion of the new heating water loop would be buried along Red Hill Road, which has a significant grade that may result in much higher difficulty and cost of construction.

The advantage of an auxiliary plant is that having a second plant would increase campus resiliency. Locating the auxiliary plant on the northeast part of campus would remove the east campus steam distribution single point failure vulnerability that was discussed earlier. Half of the steam distribution system could then be decommissioned in Phase 1 and would no longer have to be maintained. The steam plant would also only need to support the closer southern part of campus and might be able to run at a lower pressure. Furthermore, construction would not interfere with current steam plant operations. In addition, the buildings still using direct steam heating are located on south campus and their heating water conversion could therefore be delayed in this alternative.

The disadvantage of building an auxiliary plant is that it would have higher initial investment costs than simply converting the existing steam plant and maintenance would no longer be centralized.

6.4.3 Alternative 4C – New Auxiliary Heating Water Plant at Garrison Hall

In this alternative, a new auxiliary heating water plant would be built at Garrison Hall, one of the same locations proposed for a steam auxiliary plant in Alternative #2. The new plant could either be scaled up over time to eventually carry the entire campus heating water load or part of the existing steam plant could be converted to a hot water plant in a later phase instead. The new heating water plant would have seismic construction.

A northern heating water distribution loop would be completed in Phase 1 with a southern loop added in a later phase.

The advantage of this location over the plant at Reed Gym in Alternative 4B is that the new buried piping mains would be installed along relatively flat ground which would make construction easier. The other advantages and disadvantages of this alternative are the same as described in Alternative 4B.

6.4.4 Alternative 4D – New Auxiliary Heating Water Plant at Building 51

In this alternative, a new auxiliary heating water plant would be built behind Building 51, one of the same locations proposed for a steam auxiliary plant in Alternative #2. The new plant could either be scaled up over time to eventually carry the entire campus heating water load or part of the existing steam plant could be converted to a hot water plant in a later phase instead. The new heating water plant would have seismic construction.

A northern heating water distribution loop would be completed in Phase 1, same as Alternative 4C, with a southern loop added in a later phase.

The advantage of this location over the plant at Reed Gym in Alternative 4B is that the new buried piping mains would be installed along relatively flat ground that would make construction easier. The other advantages and disadvantages of this alternative are the same as described in Alternative 4C.

6.5 Considered Alternative #5: Single Project Hot Water Conversion

In this alternative, the campus steam system would be abandoned, and campus would be converted to a heating water system all at once. The conversion would be completed with one of the sub-alternatives presented in Alternative #4. The only difference being that construction would not be phased out over a long period of time. The main advantage of this alternative over the incremental conversion presented in Alternative #4 is that both the steam and heating water systems would not need to be maintained simultaneously for a long period of time, and no part of campus would have to rely on the aging steam system for a long period of time. Although the investment costs for a wholesale conversion would be considerable the total costs would likely be less than a piecemeal conversion.

It is also worth considering a smaller, building scale, CHP or cogeneration system within the hot water scenarios. Either a microturbine package or reciprocal engine generator could be employed to serve the electrical and heating needs of a single large building. The advantage of the smaller systems is decreased electrical infrastructure requirements, lower gas pressure requirements, and simpler interconnection requirements from the electrical utility. The main disadvantage of smaller scale CHP is a higher construction cost per KW of generation.

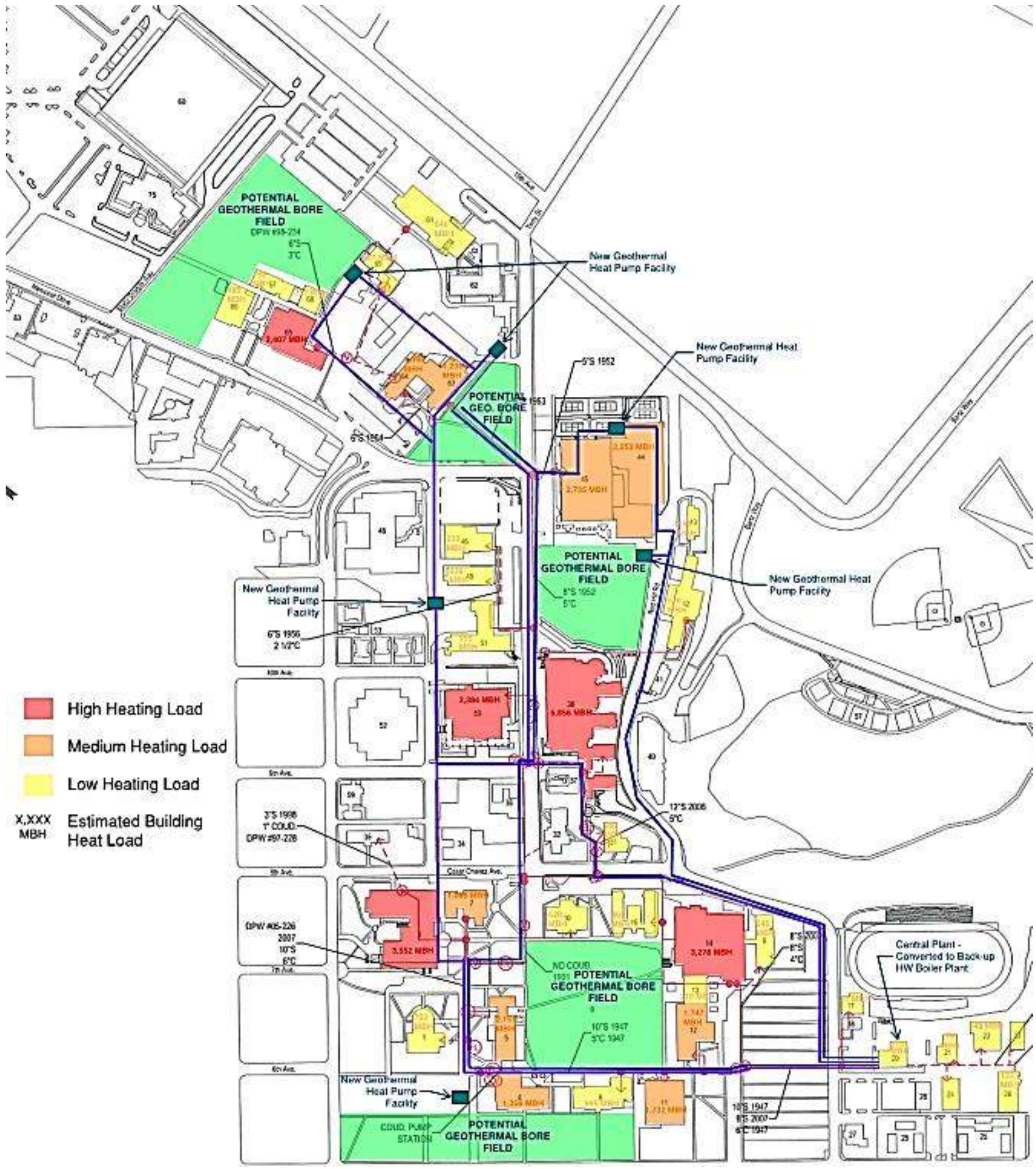
6.6 Considered Alternative #6: Incremental Heat Pump Conversion

This alternative envisions a fully electric heat pump system where water-to-water heat pumps are used to both heat and cool campus buildings. A heat pump is refrigerant and compressor system, like an air conditioner that can be reversed, alternatively heating or cooling air or liquid. It requires a source or sink of heat from which to draw. Air-to-air heat pumps, drawing or rejecting heat to the air outside, are a common form of heating in more moderate climates. A heat pump always draws heat from one side and rejects it to the other. In this case, the heat pumps would draw heat from the ground, which is below the surface and a nearly constant temperature. This is called a geothermal heat pump or, more accurately, a geo-exchange heat pump. Water is circulated through pipes buried in the ground. The pipes are arranged vertically like wells or horizontally like rows of sprinkler pipe. The area of buried piping is called a bore field.

During the summer when buildings require cooling, the heat pump would produce chilled water to cool buildings and hot water that would be sent down into the bore field where the heat would be dispersed to the earth. In the winter the heat pump would reverse, producing hot water for buildings and sending cold water into the ground to be warmed so that more heat can be extracted from it to continue heating. The design of the bore field depends on soil conditions, and the amount of heating vs cooling that would be done as the ground can become “saturated” where the temperature is semi-permanently raised or lowered receiving too much hot or cold water. For ISU, in a heating dominated climate the bore fields would have to be large enough to avoid over cooling the soil.

The map on the following page shows a broad concept of a heat pump conversion for campus. The quantity of bore field shown and the size of heat pump plants is approximate. If this alternative were selected, soils testing would be required to hone in on more accurate requirements. In addition, it is important to consider that the hottest water heat pumps can generate is only between 140°F and 150°F water. Most buildings on campus are designed for 180°F water or even steam. As interest in heat pump conversions has accelerated, the need for higher temperature output has been recognized, and there is some reason to think that heat pump technology may reach 180°F in the near future. There are small-scale industrial process heat pumps currently in production that can attain even higher output temperatures.

Each heat pump plant would include electrical switchgear, pumps, water treatment equipment (strainers and chemical feeders), controls, and the heat pumps themselves. They could be located in a standalone facility or within existing mechanical or storage space with access for piping and electrical utilities. The heat pumps would require significant electrical infrastructure, as the total peak power consumption of the heat pump would be nearly 4.5 megawatts. The location of the heat pump plants should be coordinated with utility electrical infrastructure. Locating heat pumps near existing chilled water systems would allow both cooling and heating to be served from this system. The system required for heating would also meet cooling needs for all buildings currently connected to the steam system.



Several bore fields for closed-loop geothermal heat exchange are shown (green areas on the map). The bore fields can be fields, parking lots, or other landscape area. Note that areas would be disturbed with drilling equipment during installation of the bore fields but after construction the only visible marker of the bore field would be access points to valve vaults. Several different distribution piping routes are shown – not all routes shown would be installed, the final route would depend on bore field and plant locations.

The same bore field concept can also be used and individual heat pumps installed at every building. This option would allow buildings to come online individually and would look more like the distributed heating concept explored in alternative #3.

7. Appendix

The appendix contains the following information:

1. Choosing By Advantages (CBA) table
2. Opinions of Probable Cost summaries for Master Plan phases
    a. Phase 1
    b. Phase 2a
    c. Phase 2b
3. Table of campus buildings connected to the central heat plant and estimated loads
4. Map of campus buildings connected to the central heat plant
5. Map of campus buildings by estimated load and steam system capacity
6. Drawing of existing heat plant
7. Drawing of proposed heat plant mechanical installation
8. Map of Master Plan Recommended East Campus Steam Loop
9. Considered Alternative Maps
    a. Master Plan Option 2 Maps (3 pages)
    b. Master Plan Option 4 Map (1 page)
    c. Master Plan Option 6 Map (1 page)

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Choosing By Advantages Study of: ISU District Heating System	Invest in Steam, Current Plant		Invest in Steam, Aux Plant		Move to Distributed Heating		Central Hot Water -incremental		Central Hot Water - Day1		Heat pump Systems -incremental	
	Commit to maintaining the steam distribution system and connecting new buildings built within 500ft of existing lines, invest in the current plant		Commit to maintaining the steam distribution system, connecting new buildings within 500 ft of a main. Build an Auxiliary plant to supplement the main plant		Maintain existing steam system while new buildings and major renovations have their own heating systems, prune steam lines from distribution system as possible		Maintain the existing steam system while building a new scalable hot water plant and distribution that would be scaled up over time		Rebuild the steam plant into a hot water plant, provide new distribution, renovate buildings to remove direct steam use where or add steam generators where needed		Build, and then expand, a heat pump heating system. Renovate buildings for 140 degree heating water	
Factor: Reliably generates heat (Equipment Criteria: Attribute / Advantage	Boiler #4 in place, DA , feedwater Known quantity, Controls	85	Second plant increases reliability over single plant	90	More EQ = More failures Outages are smaller	75	Two systems that do not back each other up	80	All new equipment better than steam	100	Modular EQ provides redundancy Reliability depends on source	50
Factor: Reliably distributes heat Criteria: Attribute / Advantage	Steam distribution in place, aging Tunnel is single point of failure	80	Condensate return is an issue 2nd feed = no tunnel failure point	75	Natural gas distribution only fewer HXs required	100	Two systems that do not back each other up	75	Assume loop system through campus slightly + from steam, tunnel still single point	100	HW loop, with lower temperatures	100
Factor: Minimize Utility costs Criteria: Attribute / Advantage	Steam efficiency is lower	30	Steam efficiency is lower	30	Efficient boilers can be installed More gas meters	45	Moving towards more efficient hot water	35	Better than steam avoids obsolete steam maintenance	40	Competitive with NG now likely better in the future	50
Factor: Minimize Maintenance costs Criteria: Attribute / Advantage	Central is good, steam is bad	30	Two plants increase costs	20	More EQ = More maintenance	5	Two systems to maintain HW is less costly than steam	25	Better than steam	45	No burner maintenance significant compressor maintenance	35
Factor: Minimize impact in buildings Criteria: Attribute / Advantage	Status Quo in place	10	Status Quo in place	10	High impact in buildings	1	Some impact to buildings	5	Significant impact	2	Very significant impact	0
Factor: Minimize cost in future construction Criteria: Attribute / Advantage	Plant holds heat generation costs	30	Plants hold heat generation costs	30	All new buildings need a heating plant	5	Central plant holds costs	30	Central plant is good	30	Each building likely requires a heat pump system	0
Factor: Avoid single points of failure Criteria: Attribute / Advantage	If dual fuel is added, only the tunnel compete steam loop	65	Add 2nd feed compete steam loop	70	Assume all heating plants are redundant	60	Two plants, more points of failure	60	If dual fuel is added, only the tunnel Loop new distribution	70	piping systems are only single points	70
Factor: Footprint on campus Criteria: Attribute / Advantage	Central is small footprint Plant is well placed	8	2nd plant adds to footprint	3	high overall footprint	2	HW footprint is smaller in the end Two plants for some time	6	Even more compact than steam	9	Very large footprint with ground source loop fields	0
Factor: Regional showpiece (bragging rights Criteria: Attribute / Advantage	Steam is not flashy	0	Steam is less innovative Brand new plant	2	small heat plants are common in commercial buildings	0	Template for other campuses	5	Hot water conversions are of interest	8	Very innovative	10
Factor: Minimize Carbon emissions Criteria: Attribute / Advantage	Difficult carbon reduction paths - * modify tl renewable natural gas potential	0	Difficult carbon reduction paths - * modify tl renewable natural gas potential	5	More efficient boilers reduce emissions, more future flexibility	20	More efficient boilers reduce emissions, more future flexibility	20	Slightly better than steam at start electric boiler offramp, maybe future heat pump	10	Best carbon performance	50
Factor: Operates on multiple fuel sources Criteria: Attribute / Advantage	Second fuel source will be installed	80	Second fuel source will be installed	80	Individual plants would not be dual fuel	0	Can be duel fuel	70	Will be duel fuel	80	Electric only - emergency gen? Does any heat operate without grid power?	40
Factor: Future ready - flexible solution for tl Criteria: Attribute / Advantage	Steam limits options Electric steam boilers possible	5	Steam Limits options Second plant adds flexibility	10	New buildings get new tech Renovation by building	25	Hot water is more flexible than steam	20	Hot water is more flexible than steam	20	Future ready	30
Factor: Nox emissions Criteria: Attribute / Advantage	Central sources easier to reduce emissions No real restrictions yet	5	Central sources easier to reduce emissions No real restrictions yet	5	More overall emissions with this route	0	New burners can be low Nox	3	New burners can be low Nox	3	No Local NOX	10
Factor: Criteria: Attribute / Advantage												
Total Importance		428		430		338		434		517		445
Capital Cost	$8,399,000		$10,872,000		$33,453,000		39-44 Million		$41,809,000		$59,000,000	

OPINION OF PROBABLE COSTS

PROJECT NUMBER	**PROJECT TITLE**	**DATE**	8/30/2021
20229	**Idaho State University - Master Plan**		
PROBABLE COSTS BY	Concept Level Opinion of Cost for Phase 1 Project	**RMH PROJECT NUMBER**	
Jeff Elsner		20229	

Scope: Install new 50 Mlb/hr boiler, remove boiler #1 and #2, install compressed air and fuel oil system, seismically brace equipment in original plant, internally brace original building to limit seismic, building exterior to remain.
Existing building is 3355 square feet

SUMMARY	MATERIALS	LABOR	State of Idaho Tax	General Conditions (Mob/Demobe Cleanup, Protection)	Escalation	Design Services	Bond and Permit	Design Contingency	TOTAL
	***	***	6%	30.0%	10.0%	10.0%	3.0%	15.0%	
Equipment	$2,136,272	$92,445	$128,176	$668,615	$222,872	$312,020	$66,862	$334,308	$3,961,571
Piping	$218,392	$199,185	$13,103	$125,273	$41,758	$58,461	$12,527	$62,636	$731,335
Controls and instrumentation	$7,421	$62,748	$445	$21,051	$7,017	$9,824	$2,105	$10,525	$121,137
Electrical upgrades	$50,104	$90,833	$3,006	$42,281	$14,094	$19,731	$4,228	$21,141	$245,418
ISU Costs (Not Included)									
Architectural	$76,220	$109,789	$4,573	$55,803	$18,601	$26,041	$5,580	$27,901	$324,508
Structural	$402,992	$321,473	$24,179	$217,339	$72,446	$101,425	$21,734	$108,670	$1,270,258
	$2,891,401	$876,473		$1,130,362	$376,787	$527,502	$113,036	$565,181	

Contractor Base Labor Rate: $82

TOTAL = $6,654,228

OPINION OF PROBABLE COSTS

PROJECT NUMBER	**PROJECT TITLE**	**DATE**	8/30/2021
20229	**Idaho State University - Master Plan**		
PROBABLE COSTS BY	Concept Level Opinion of Cost for Phase 2A Project	**RMH PROJECT NUMBER**	
Jeff Elsner		20229	

Complete East Campus Steam/Condensate Loop from Reed Gymnasium through Rendezvous with direct-buried piping across Cadet Field

SUMMARY	MATERIALS ***	LABOR ***	State of Idaho Tax 6%	General Conditions (Mob/Demobe Cleanup, Protection) 15.0%	Escalation 10.0%	Design Services 10.0%	Bond and Permit 3.0%	Design Contingency 15.0%	TOTAL
Equipment									
Piping	$895,823	$398,858	$53,749	$194,202	$129,468	$161,835	$38,840	$194,202	$2,066,977
Controls and instrumentation	$36,884	$7,245	$2,213	$6,619	$4,413	$5,516	$1,324	$6,619	$70,833
Electrical upgrades	$1,598	$7,400	$96	$1,350	$900	$1,125	$270	$1,350	$14,088
ISU Costs									
Architectural	$4,219	$27,675	$253	$4,784	$3,189	$3,987	$957	$4,784	$49,848
Structural	$5,486	$8,384	$329	$2,081	$838	$1,679	$416	$2,081	$21,294
	$944,010	$449,561		$209,036	$138,808	$174,141	$41,807	$209,036	

Contractor Base Labor Rate: $82

TOTAL = $2,223,039

OPINION OF PROBABLE COSTS

PROJECT NUMBER	PROJECT TITLE	DATE 8/30/2021
20229	**Idaho State University - Master Plan**	
PROBABLE COSTS BY	Concept Level Opinion of Cost for Phase 2b Project	**RMH PROJECT NUMBER**
Jeff Elsner		20229

Scope: Install new 50 Mlb/hr boiler, remove boiler #1 and #2, install compressed air and fuel oil system, seismically brace equipment in original plant, internally brace original building to limit seismic, building exterior to remain.
Existing building is 3355 square feet

SUMMARY	MATERIALS ***	LABOR ***	State of Idaho Tax 6%	General Conditions (Mob/Demobe Cleanup, Protection) 30.0%	Escalation 10.0%	Design Services 10.0%	Bond and Permit 3.0%	Design Contingency 15.0%	TOTAL
Equipment	$1,669,022	$3,050	$100,141	$501,622	$167,207	$234,090	$50,162	$250,811	$2,976,105
Piping	$49,027	$64,294	$2,942	$33,996	$11,332	$15,865	$3,400	$16,998	$197,854
Controls and instrumentation	$2,303	$28,784	$138	$9,326	$3,109	$4,352	$933	$4,663	$53,608
Electrical upgrades	$5,149	$15,482	$309	$6,189	$2,063	$2,888	$619	$3,095	$35,795
ISU Costs (Not Included)									
Architectural	$10,202	$22,834	$612	$9,911	$3,304	$4,625	$991	$4,955	$57,434
Structural	$89,379	$47,207	$5,363	$40,976	$13,659	$19,122	$4,098	$20,488	$240,291
	$1,825,081	$181,652		$602,020	$200,673	$280,943	$60,202	$301,010	

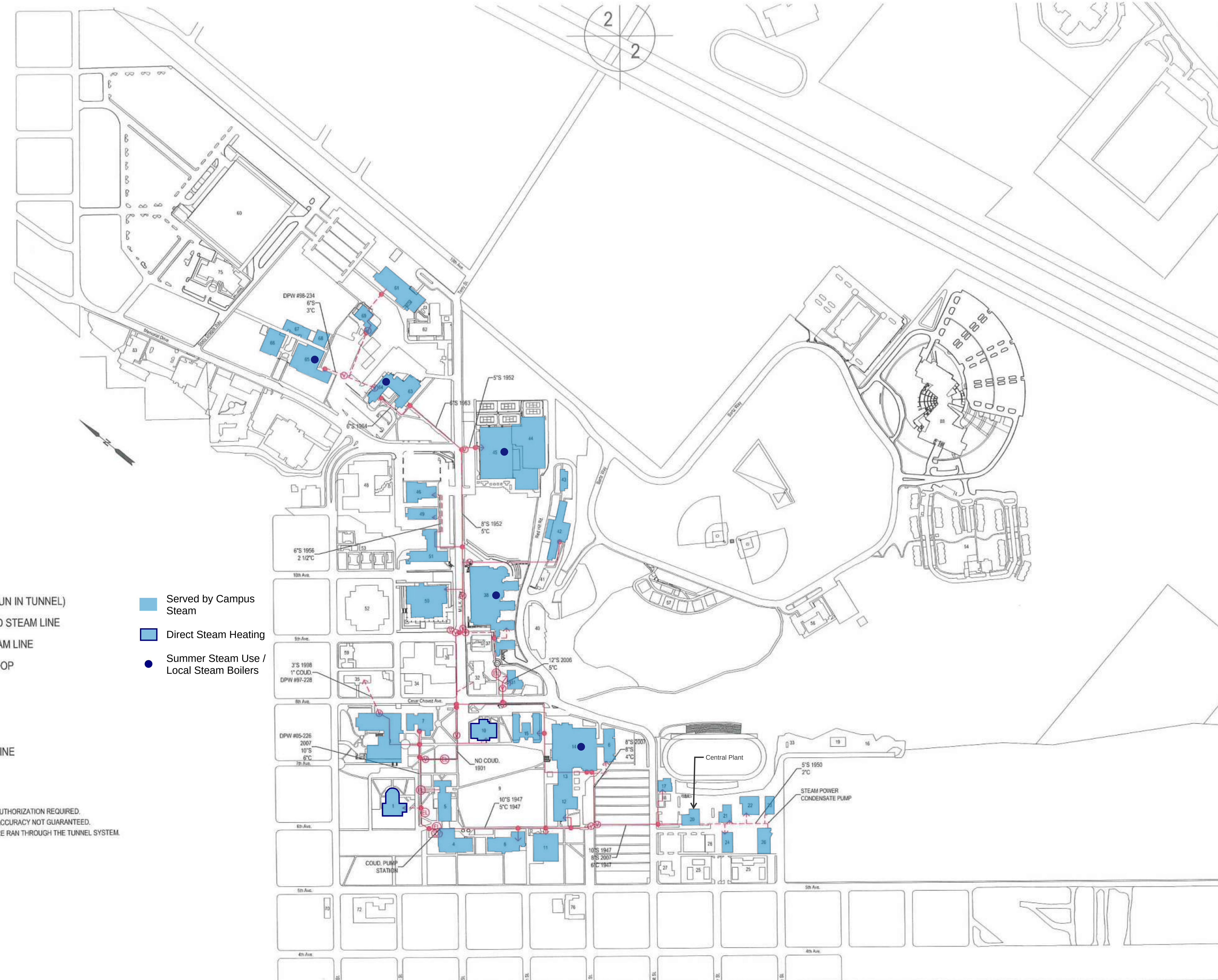
Contractor Base Labor Rate: $82

TOTAL = $3,561,086

Building Number	Building Name	Type	Type for Heating Calculation	Stories	Square footage	Envelope Sqr ft	On Steam?	Heat	Heat Load	Steam Load	Steam lIne size
							Y/N	Btuh/sf	MBH	lbs/hr	"
38	Rendevous (see housing belov	Mixed use/Commor	Assembly/Multi-purpose	3	231526	321000	Y	25.29	5856.33	5685.76	
3	Physical Science - Complex	Class/Lab	Classroom	3	154471	176542	y	23.00	3552.06	3448.60	
65	Biology (Gale)	Lab (1+4 story)	Lab	3	84673	95538	Y	40.24	3407.35	3308.10	? <6
50	Library - ELI M Oboler	Library	Library	3	163513	173414	Y	20.70	3383.98	3285.42	4
14	Student Union & Bookstore		Assembly/Multi-purpose		129595	142760	Y	25.29	3278.04	3182.56	
45	Reed Gymnasium		Assembly/Multi-purpose	1	108122	132658	Y	25.29	2734.89	2655.23	5
44	Student Rec Center		Assembly/Multi-purpose		89088	98197	Y*	25.29	2253.44	2187.80	
5	Business Administation		Classroom	4	93534	104316	Y	23.00	2150.81	2088.17	6
12	Museum	Musueam/Office	Assembly/Multi-purpose	4	69076	76223	Y	25.29	1747.24	1696.35	
11	Fine Arts	Class/Performance	Classroom	3	75335	91307	Y	23.00	1732.33	1681.87	3
4	Liberal Arts - Kegel	Classroom	Classroom	3	58952	65832	Y*	23.00	1355.60	1316.12	
63	Garrison Hall	Office (former res h	Office	7	76826	83794	Y	16.10	1236.63	1200.61	
64	Turner House	Housing - Dorm	Residence		68065	77315	Y	16.10	1095.61	1063.70	
7	Engineering - Lilibridge	Class/Lab	Lab	2	27038	30346	Y	40.24	1088.04	1056.35	4
8	Pharmacy - Leonard Hall	Class/Lab	Classroom	2.5	43255	49275	Y	23.00	994.65	965.68	4
51	Trade & Technology		Classroom	1	41551	45347	Y	23.00	955.47	927.64	4
15	Graveley Hall	Office (former res h	Office	3	49939	57682	Y	16.10	803.84	780.43	
1	Frazer Hall	Classroom	Classroom	2	32683	45663	Y	23.00	751.55	729.66	6
42	Owen Redfield Complex	Housing - Dorm	Residence	3	41967	47237	Y	16.10	675.52	655.85	6
61	Albion Hall	Classroom	Classroom	2	28156	27139	Y*	23.00	647.45	628.59	
10	Administration	Office	Office	3	38542	43439	Y	16.10	620.39	602.32	?
6	Early Learning Center	Daycare	Classroom	2	23501	26213	Y	23.00	540.41	524.67	
46	Vocational Arts		Classroom	1	23180	25649	Y*	23.00	533.02	517.50	
66	Nursing - Beckley	Office	Office	1.5	30109	33823	Y*	16.10	484.65	470.53	
69	Plant Sciences	Greenhouse	Lab	1	9126	9701	Y	40.24	367.24	356.55	
68	Speech Pathology - Audiology	Office/Classroom	Classroom	2	15531	17781	Y*	23.00	357.14	346.73	
31	Student Health Center		Classroom	2	12162	13813	Y	23.00	279.67	271.52	1.5
49	Estec	Shops	Storage/Shops	2	19656	21263	Y*	11.50	225.99	219.41	
20	Heat Plant		Office		13048	19578	Y*	16.10	210.03	203.91	
13	Hypostle		Assembly/Multi-purpose		7921	8729	Y*	25.29	200.36	194.52	
67	Lecture Center		Classroom		8364	12055	Y*	23.00	192.33	186.73	
43	Dyer Hall	Housing - Dorm	Residence		11193	12487	Y*	16.10	180.17	174.92	
22	Ships		Storage/Shops		12983	14014	Y*	11.50	149.27	144.92	
26	Shipping and Receiving - shops		Storage/Shops		11578	20024	Y*	11.50	133.12	129.24	
21	Transportation services shop		Storage/Shops		6840	11200	Y*	11.50	78.64	76.35	
17	Davis Field House	Field	Storage/Shops		4401	5825	Y	11.50	50.60	49.13	2.5
38	Rendevous (see above)	Housing Apartment:	Residence				Y	16.10	0.00	0.00	
23	Bengal Depot						Y*		0.00	0.00	
24	Custodial/Welding						Y*		0.00	0.00	
				Steam System Total:	**1,915,500.00**				**44,303.86**	**43,013.45**	
				Campus Total:	**2,422,553.00**				**55,792.41**	**54,167.38**	
				Campus BTU/sf	**23.03**						
				Steam system BTU/sf	**23.13**						

Building Number	Building Name	Type	Type for Heating Calculation	Stories	Square footage	Envelope Sqr ft	On Steam?	Heat	Heat Load	Steam Load	Steam lIne size
							Y/N	Btuh/sf	MBH	lbs/hr	"
38	Rendevous (see housing belov	Mixed use/Commor	Assembly/Multi-purpose	3	231526	321000	Y	25.29	5856.33	5685.76	
60	Holt Arena	Fieldhouse	Assembly/Multi-purpose	1	168525	264793	N	25.29	4262.76	4138.60	
3	Physical Science - Complex	Class/Lab	Classroom	3	154471	176542	y	23.00	3552.06	3448.60	
65	Biology (Gale)	Lab (1+4 story)	Lab	3	84673	95538	Y	40.24	3407.35	3308.10	? <6
50	Library - ELI M Oboler	Library	Library	3	163513	173414	Y	20.70	3383.98	3285.42	4
14	Student Union & Bookstore		Assembly/Multi-purpose		129595	142760	Y	25.29	3278.04	3182.56	
88	Performing Arts - Stephens	Theater/Performan	Assembly/Multi-purpose		111286	181727		25.29	2814.92	2732.94	
45	Reed Gymnasium		Assembly/Multi-purpose	1	108122	132658	Y	25.29	2734.89	2655.23	5
44	Student Rec Center		Assembly/Multi-purpose		89088	98197	Y*	25.29	2253.44	2187.80	
5	Business Administation		Classroom	4	93534	104316	Y	23.00	2150.81	2088.17	6
12	Museum	Musueam/Office	Assembly/Multi-purpose	4	69076	76223	Y	25.29	1747.24	1696.35	
11	Fine Arts	Class/Performance	Classroom	3	75335	91307	Y	23.00	1732.33	1681.87	3
4	Liberal Arts - Kegel	Classroom	Classroom	3	58952	65832	Y*	23.00	1355.60	1316.12	
63	Garrison Hall	Office (former res h	Office	7	76826	83794	Y	16.10	1236.63	1200.61	
64	Turner House	Housing - Dorm	Residence		68065	77315	Y	16.10	1095.61	1063.70	
7	Engineering - Lilibridge	Class/Lab	Lab	2	27038	30346	Y	40.24	1088.04	1056.35	4
8	Pharmacy - Leonard Hall	Class/Lab	Classroom	2.5	43255	49275	Y	23.00	994.65	965.68	4
62	College of Education		Classroom		41847	46981		23.00	962.27	934.24	
51	Trade & Technology		Classroom	1	41551	45347	Y	23.00	955.47	927.64	4
15	Graveley Hall	Office (former res h	Office	3	49939	57682	Y	16.10	803.84	780.43	
1	Frazer Hall	Classroom	Classroom	2	32683	45663	Y	23.00	751.55	729.66	6
40	Red Hill		Classroom	2	30664	33660	N	23.00	705.12	684.58	
42	Owen Redfield Complex	Housing - Dorm	Residence	3	41967	47237	Y	16.10	675.52	655.85	6
61	Albion Hall	Classroom	Classroom	2	28156	27139	Y*	23.00	647.45	628.59	
10	Administration	Office	Office	3	38542	43439	Y	16.10	620.39	602.32	?
6	Early Learning Center	Daycare	Classroom	2	23501	26213	Y	23.00	540.41	524.67	
75	Sports and Ortho Center		Classroom		23261	24492	N	23.00	534.89	519.31	
46	Vocational Arts		Classroom	1	23180	25649	Y*	23.00	533.02	517.50	
66	Nursing - Beckley	Office	Office	1.5	30109	33823	Y*	16.10	484.65	470.53	
25	University Courts	Housing Apartment	Residence		28124	31592		16.10	452.70	439.51	
69	Plant Sciences	Greenhouse	Lab	1	9126	9701	Y	40.24	367.24	356.55	
68	Speech Pathology - Audiology	Office/Classroom	Classroom	2	15531	17781	Y*	23.00	357.14	346.73	
83	Family medicine - family dent	Med Office	Office	1	20426	22658		16.10	328.79	319.21	
72	West Campus	Housing Apartment	Residence		18905	26898		16.10	304.30	295.44	
31	Student Health Center		Classroom	2	12162	13813	Y	23.00	279.67	271.52	1.5
37	Dental Hygene Clinic	Active dental Clinic	Lab	1	6076	6552		40.24	244.51	237.38	
49	Estec	Shops	Storage/Shops	2	19656	21263	Y*	11.50	225.99	219.41	
20	Heat Plant		Office		13048	19578	Y*	16.10	210.03	203.91	
13	Hypostle		Assembly/Multi-purpose		7921	8729	Y*	25.29	200.36	194.52	
35	Colonial Hall	Office	Office	2	12050	14534		16.10	193.96	188.31	
67	Lecture Center		Classroom		8364	12055	Y*	23.00	192.33	186.73	
43	Dyer Hall	Housing - Dorm	Residence		11193	12487	Y*	16.10	180.17	174.92	
41	Nichols Hall	Housing - Dorm	Residence		11182	12487		16.10	179.99	174.75	
32	Dental Sciences	Office	Office	1	9478	10809		16.10	152.56	148.12	
22	Ships		Storage/Shops		12983	14014	Y*	11.50	149.27	144.92	
26	Shipping and Receiving - shops		Storage/Shops		11578	20024	Y*	11.50	133.12	129.24	
27	Public Safety	Offices	Office	1	8202	8671		16.10	132.02	128.18	
18	Facilities Services	facilities	Office	1.5	5137	5020		16.10	82.69	80.28	
21	Transportation services shop		Storage/Shops		6840	11200	Y*	11.50	78.64	76.35	
19	Grounds Shop		Office		4078	4198		16.10	65.64	63.73	

28	Art/Museum Storage		Storage/Shops		4937	5126		11.50	56.76	55.11	
17	Davis Field House	Field	Storage/Shops		4401	5825	Y	11.50	50.60	49.13	2.5
16	Hazardous Waste		Office		911	1016		16.10	14.66	14.24	
38	Rendevous (see above)	Housing Apartments	Residence				Y	16.10	0.00	0.00	
48	College of Technology	Office-Class-Food	Classroom	3				23.00	0.00	0.00	
52	LDS Institute of Religion	Private entity	Assembly/Multi-purpose					25.29	0.00	0.00	
53	Pulling Courts	Housing Apartments	Residence					16.10	0.00	0.00	
54	Ridge Crest	Housing Apartments	Residence					16.10	0.00	0.00	
56	Schubert Heights	Housing Apartments	Residence					16.10	0.00	0.00	
57	McIntosh Manor	Housing Apartments	Residence					16.10	0.00	0.00	
70	5th Street Apartments	Housing Apartments	Residence					16.10	0.00	0.00	
81	Nursing Home - Pocatello Care & Rehab		Lab					40.24	0.00	0.00	
2	Swanson Arch	Ornamental		0					0.00	0.00	
9	Quadrangle - Hutchinson Mem	Quad		0					0.00	0.00	
23	Bengal Depot						Y*		0.00	0.00	
24	Custodial/Welding						Y*		0.00	0.00	
33	Fuel Station								0.00	0.00	
34	St. John's Center	Private entity							0.00	0.00	
36	University Bible Church	Private entity							0.00	0.00	
47	Cadet Field	Field							0.00	0.00	
55	Bartz Field	Field							0.00	0.00	
59	Credit Union - ISU Federal	Private entity							0.00	0.00	
78	Information Booth				103	108			0.00	0.00	
82	Human Development Center	Field/Quad not a building		0					0.00	0.00	
55a	Miller Ranch Stadium				1861	2224			0.00	0.00	
55b	rugby field			Field					0.00	0.00	
60a	Practice Field	Field		0					0.00	0.00	
				Steam System Total:	**1,915,500.00**				**44,303.86**	**43,013.45**	
				Campus Total:	**2,422,553.00**				**55,792.41**	**54,167.38**	
				Campus BTU/sf	**23.03**						
				Steam system BTU/sf	**23.13**						



STEAM LINE (RUN IN TUNNEL)

DIRECT BURIED STEAM LINE

ENCASED STEAM LINE

EL EXPANSION LOOP

V VALVE

SERVICE

S STEAM LINE

C CONDENSER LINE

Served by Campus Steam

Direct Steam Heating

Summer Steam Use / Local Steam Boilers

NOTES:

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(208) 282-4618 FAX

STEAM LINES
IDAHO STATE UNIVERSITY
ADDRESS

IDAHO STATE UNIVERSITY

BUILDING NUMBER	---
LEVEL	---
DISCIPLINE	Civil
DRAWING SCALE	NONE
UPDATE DATE	08/24/2011

STEAM LINES
IDAHO STATE UNIVERSITY
ADDRESS

	Steam Pipe Capacity (lbs/hr) w/ Press. drop of 1/2 psi per 100 ft or less			
	60 psig		100 psig	
	100 ft/s	80 ft/s	100 ft/s	80 ft/s
6" Sch. 40	10,950 (86 ft/s, 1/2 psi per 100 pd)		13,420 (72 ft/s, 1/2 psi per 100 pd)	
8" Sch. 40	21,500	17,200	27,930 (87 ft/s, 1/2 psi per 100 pd)	
10" Sch. 40	34,000	27,000	50,970	40,500
12" Sch. 40	48,000	38,500	72,000	57,500

STEAM LINE (RUN IN TUNNEL)
DIRECT BURIED STEAM LINE
ENCASED STEAM LINE
EL EXPANSION LOOP
V VALVE
SERVICE
S STEAM LINE
C CONDENSER LINE

High Steam Load
Medium Steam Load
Low Steam Load
X,XXX PPH Estimated Building Steam Load

NOTES:

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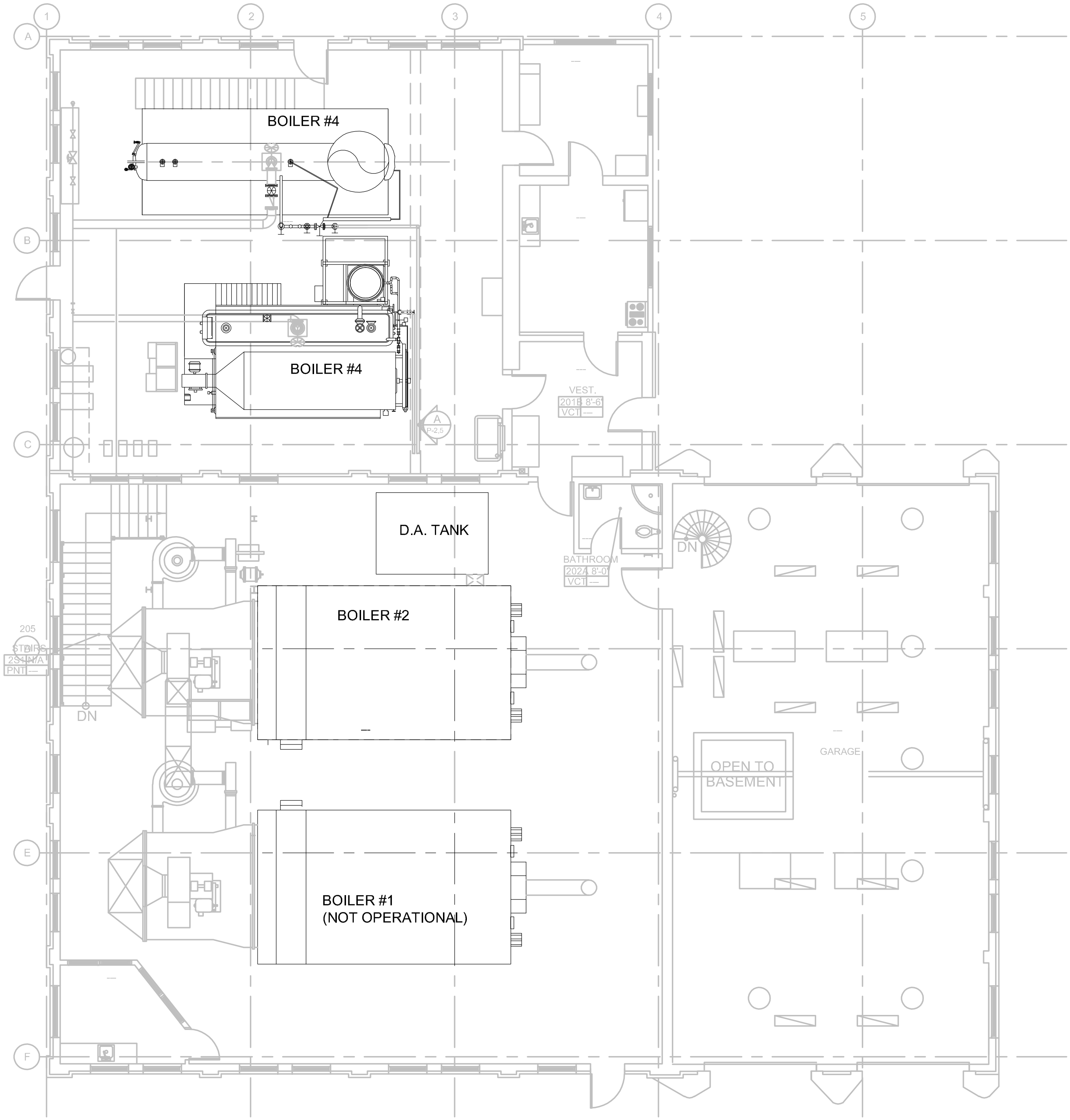
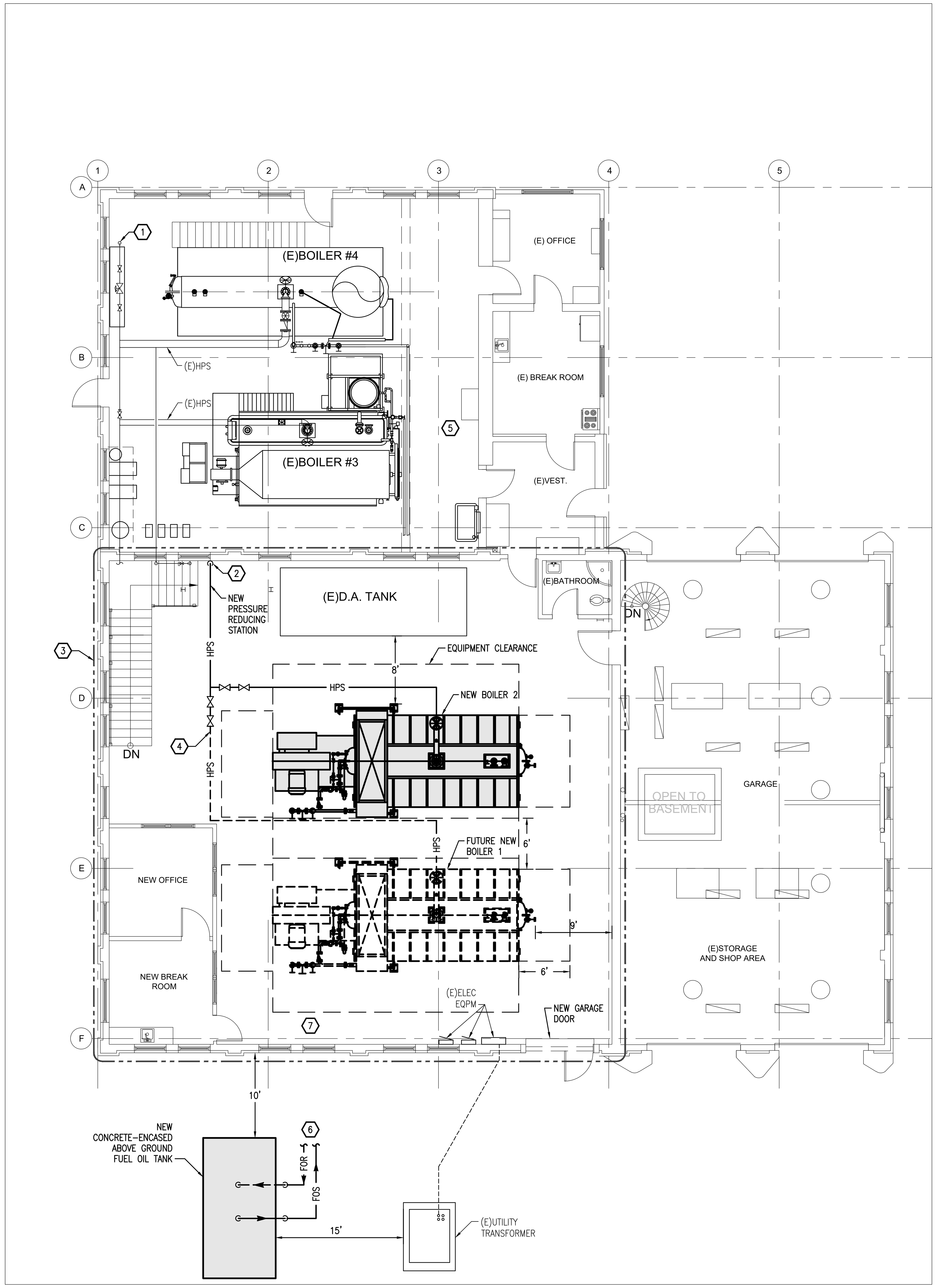
IDAHO STATE UNIVERSITY

BUILDING NUMBER	---
LEVEL	---
DISCIPLINE	Civil
DRAWING SCALE	NONE
UPDATE DATE	08/24/2011



EXISTING HEATING PLANT DRAWING

THESE DRAWINGS ARE A PROGRESS SET AND ARE, BY THEIR NATURE, INCOMPLETE. THEY ARE NOT SUITABLE FOR BIDDING OR CONSTRUCTION. ANY ATTEMPT TO ESTABLISH CONSTRUCTION COSTS FROM THESE DOCUMENTS MUST BE DONE WITH EXTREME CAUTION. COST ALLOWANCES MUST BE PROVIDED FOR DESIGN ELEMENTS AND MATERIALS NOT YET INDICATED ON THESE DOCUMENTS. THE RMH GROUP HAS NO RESPONSIBILITY OR LIABILITY FOR COSTS OF CONSTRUCTION ASSOCIATED WITH DESIGN ELEMENTS AND MATERIALS NOT YET SHOWN ON THESE DOCUMENTS.



1 M1.00 HEAT PLANT MASTER PLAN PHASE 1 – CONCEPTUAL MECHANICAL INSTALLATION PLAN

SCALE: 1/8"=1'-0"

SHEET NOTES

1. EXISTING CONDITIONS ARE TAKEN FROM EXISTING DRAWINGS AND FIELD OBSERVATION. ACTUAL CONDITIONS MAY VARY FROM WHAT IS SHOWN.

KEY NOTES

1. EXISTING STEAM HEADER FOR BOILER #4. THIS HEADER WILL REMAIN AS IS IN THE NEAR TERM WITHOUT SEISMIC BRACING.
2. CONNECT NEW HEADER FOR BOILER #2 AND FUTURE BOILER #1 TO EXISTING 10" PIPING ABOVE FLOOR. PROVIDE SEISMIC BRACING FOR THIS LINE WITHIN THE EXISTING PLANT AND EXISTING TUNNEL NORTH TO COLUMN LINE A.
3. WITHIN THIS BUILDING PROVIDE SEISMIC BRACING FOR THE EXISTING STRUCTURE, NEW PIPING, NEW EQUIPMENT, AND EXISTING FEEDWATER SYSTEM. THE EXISTING BUILDING STRUCTURE IS BOARD FORMED CONCRETE WITH EXTERIOR FACE BRICK. A DETAILED DESIGN STUDY AND DETERMINATION OF EXISTING REINFORCING INSIDE THE CONCRETE WILL BE REQUIRED TO DEVELOP A SEISMIC BRACING STRATEGY. ALL INTERIOR BRACING SHOULD BE COMPLETED PRIOR TO INSTALLING THE BOILERS AND PIPING MAINS. SEISMIC MEASURES FOR THE EXTERIOR BRICK CAN BE DIFFERED IF POSSIBLE.
4. PREPARE FOR INSTALLATION OF FUTURE BOILER #1 OR TEMPORARY BOILER BY PROVIDING DOUBLE ISOLATION VALVES WITH DRAIN AND VENT BETWEEN THEM AND BLIND FLANGE SO THAT CONNECTION CAN BE MADE WHILE THE SYSTEM IS HOT.
5. EXTEND NATURAL GAS MAIN, WITHOUT REDUCING, TO BOILER #2 WITH FULL SIZE CAP AND VALVE FOR FUTURE BOILER #1.
6. EXTEND FUEL OIL PIPING TO CONNECT TO NEW BOILER #2 AND EXISTING BOILER #4 WITH CAP AND VALVE FOR CONNECTION TO FUTURE BOILER #1. DESIGN SHOULD CONSIDER THE USE OF A DAY TANK INSIDE THE PLANT TO ALLOW FOR WARMER FUEL DURING A COLD START.
7. PROVIDE A PERMANENT FIXED COMPRESSED AIR SYSTEM FOR FUEL OIL ATOMIZING AT BURNERS. SYSTEM CAN BE LOCATED IN THE BASEMENT.

MAJOR MECHANICAL EQUIPMENT SCHEDULE

NAME	YEAR INSTALLED	CAPACITY	SEISMIC BRACING Y/N	ELECTRICAL HP	ELECTRICAL V/PH	MANUFACTURER	NOTES
(E) BOILER #3	1957	20,000 PPH OUTPUT	N	?	?	???	
(E) BOILER #4	2005	60,000 PPH OUTPUT	N	?	208/3	VICTORY ENERGY KEYSTONE 15M	
NEW BOILER #2	PHASE 1 OF MASTERPLAN	50,000 PPH OUTPUT	Y	75	208/3	CLEAVER BROOKS	1
FUTURE BOILER #1	PHASE 2B OF MASTERPLAN	50,000 PPH OUTPUT	Y	75	208/3	CLEAVER BROOKS	1
(E) DEAEARATOR	2005	2,100 GALLONS STORAGE - 100,000 PPH OUTPUT	Y	N/A	N/A	LOCKWOOD 100SS	
NEW FUEL OIL TANK	PHASE 1 OF MASTERPLAN	5,000 GALLONS	Y	2 x 1-1/2	N/A	CONVAULT	2

GENERAL NOTES:

A. PERFORMANCE IS AT SITE CONDITIONS

NOTES:

1. PROVIDE WITH STACK, ECONOMIZER AND LOW NOX BURNER.
2. CONCRETE ENCASED. PROVIDE WITH MOUNTED FUEL OIL PUMPS.
3.
4.
5.
6.

* THERMAL, COMBUSTION OR AFUE EFFICIENCY PER ASHRAE 90.1

REV.	DATE	DESCRIPTION

RMH GROUP
Denver // Phoenix
12600 West Colfax Avenue
Suite A-400
Lakewood, Colorado 80215
Phone 303-239-0909
www.rmhgroup.com © 2021
making a difference through engineering℠
Mechanical • Electrical
Industrial • Sustainability

IDAHO STATE UNIVERSITY
HEAT PLANT MASTER PLAN

HEAT PLANT MECHANICAL PLAN
PHASE 1

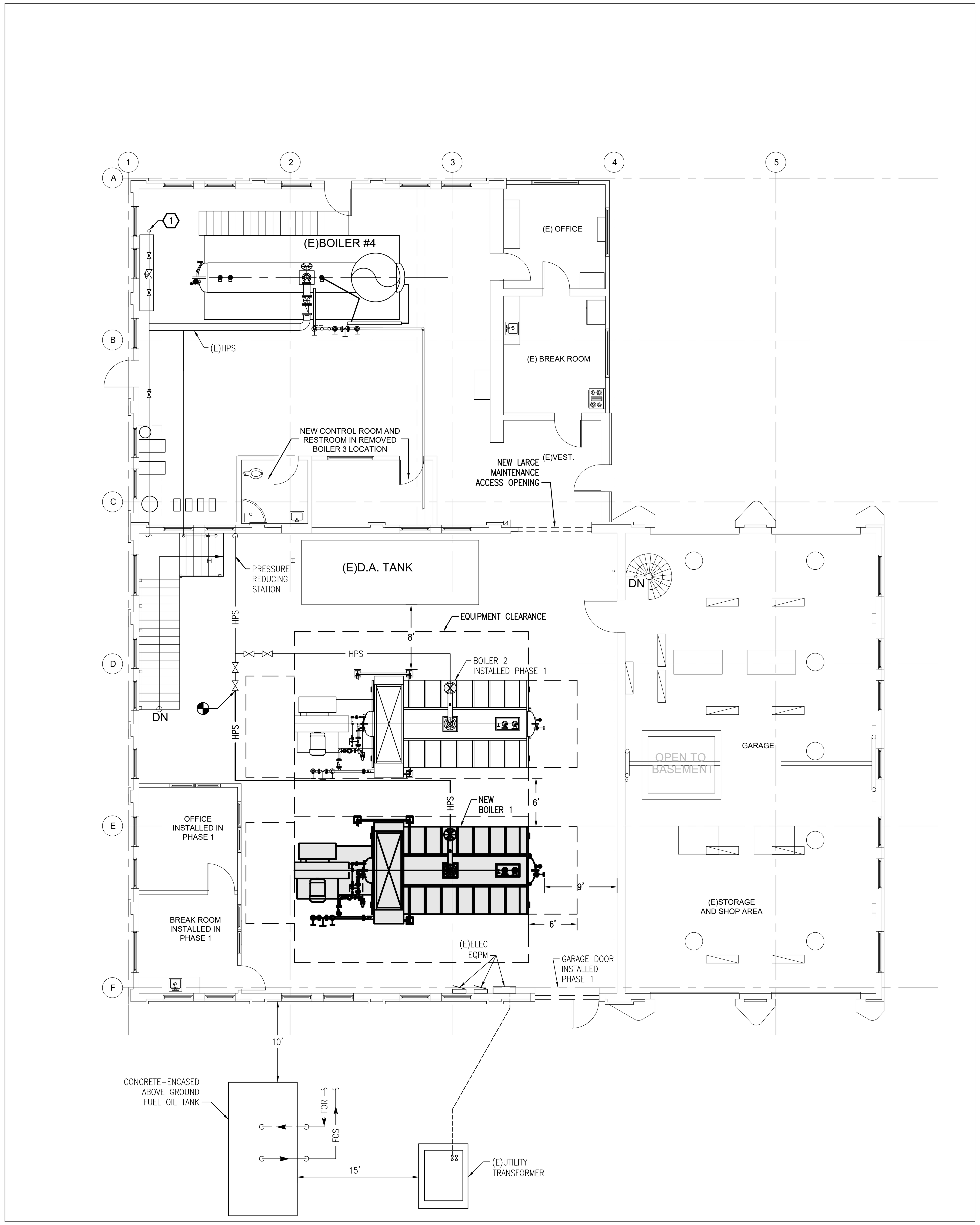
DATE: JUNE 25, 2021
SCALE: 1/8"=1'-0"
DESIGN BY: DESIGNED
DRAWN BY: DRAFT
APPROVED BY: APPROVED BY
PRJ. NO. 20229

SHT.NO.
M1.00

REVISION

Created on 7/21/2021

THESE DRAWINGS ARE A PROGRESS SET AND ARE, BY THEIR NATURE, INCOMPLETE. THEY ARE NOT SUITABLE FOR BIDDING OR CONSTRUCTION. ANY ATTEMPT TO ESTABLISH CONSTRUCTION COSTS FROM THESE DOCUMENTS MUST BE DONE WITH EXTREME CAUTION. COST ALLOWANCES MUST BE PROVIDED FOR DESIGN ELEMENTS AND MATERIALS NOT YET INDICATED ON THESE DOCUMENTS. THE RMH GROUP HAS NO RESPONSIBILITY OR LIABILITY FOR COSTS OF CONSTRUCTION ASSOCIATED WITH DESIGN ELEMENTS AND MATERIALS NOT YET SHOWN ON THESE DOCUMENTS.



1 M2.00 HEAT PLANT MASTER PLAN PHASE 2B — CONCEPTUAL MECHANICAL INSTALLATION PLAN

SCALE: 1/8"=1'-0"

SHEET NOTES

1. EXISTING CONDITIONS ARE TAKEN FROM EXISTING DRAWINGS AND FIELD OBSERVATION. ACTUAL CONDITIONS MAY VARY FROM WHAT IS SHOWN.

KEY NOTES

1. EXISTING STEAM HEADER FOR BOILER #4. THIS HEADER WILL REMAIN AS IS IN THE NEAR TERM WITHOUT SEISMIC BRACING.

REV.	DATE	DESCRIPTION

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Mechanical • Electrical
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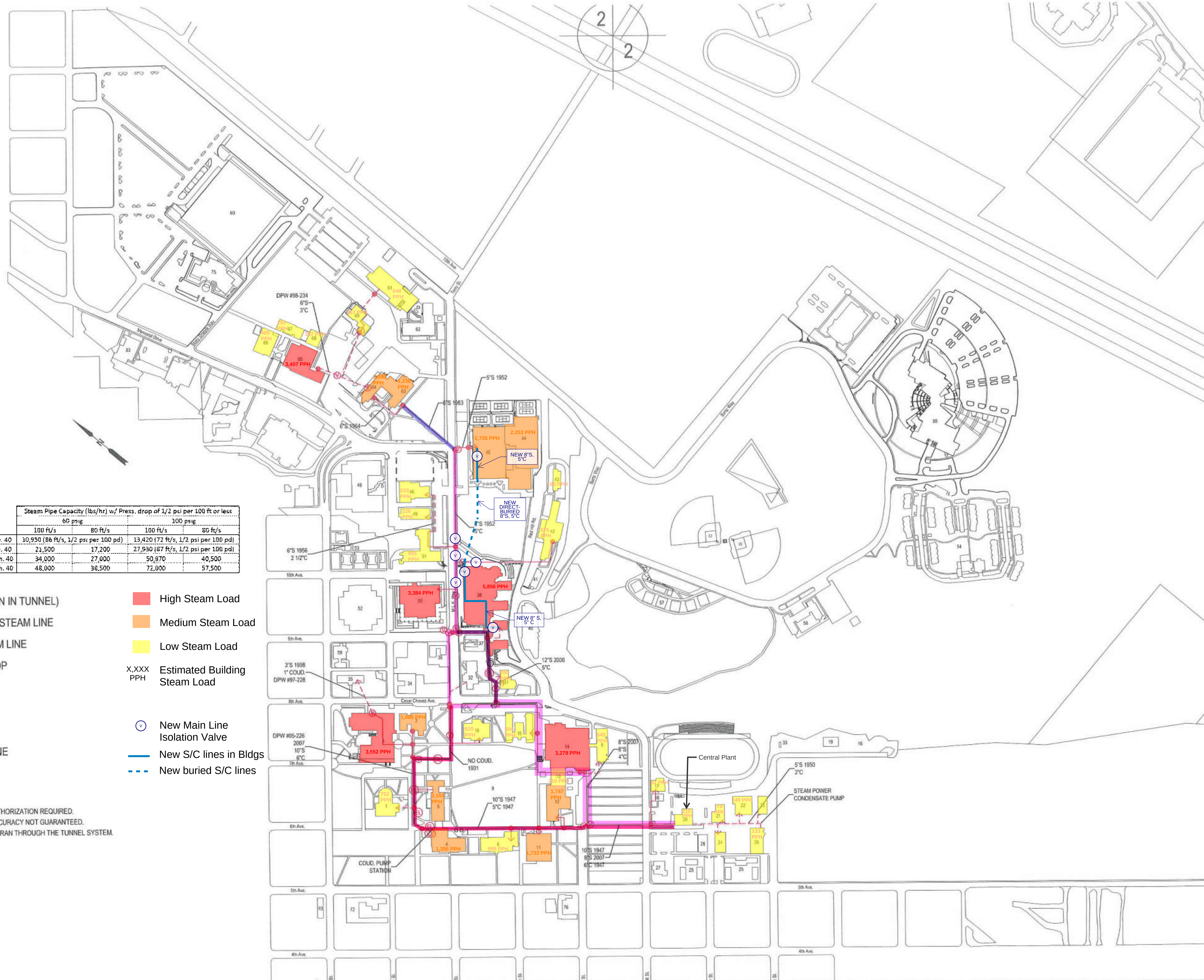
IDAHO STATE UNIVERSITY
HEAT PLANT MASTER PLAN

HEAT PLANT MECHANICAL PLAN
PHASE 2B

DATE: JUNE 25, 2021
SCALE: 1/8"=1'-0"
DESIGN BY: DESIGNED
DRAWN BY: DRAFT
APPROVED BY: APPROVED BY
PRJ. NO: 20229

SHT.NO. M2.00
REVISION

Created on 7/22/2021
File Path: W:\Jobs20\20229\1Dwgs\AutoCAD\Sheets\Heat Plant CAD Steam Sketch.dwg
Save Date 22-Jul-21 by tcioth
Plotted on 8/4/2021 by Cioth, Talia



	Steam Pipe Capacity (lbs/hr) w/ Press. drop of 1/2 psi per 100 ft or less			
	60 psig		100 psig	
	100 ft/s	80 ft/s	100 ft/s	80 ft/s
6" Sch. 40	10,950 (86 ft/s, 1/2 psi per 100 pd)		13,420 (72 ft/s, 1/2 psi per 100 pd)	
8" Sch. 40	21,500	17,200	27,930 (87 ft/s, 1/2 psi per 100 pd)	
10" Sch. 40	34,000	27,000	50,970	40,500
12" Sch. 40	48,000	36,500	72,000	57,500

EXISTING

- STEAM LINE (RUN IN TUNNEL)
- DIRECT BURIED STEAM LINE
- ENCASED STEAM LINE
- EL EXPANSION LOOP
- V VALVE
- SERVICE
- S STEAM LINE
- C CONDENSER LINE

- High Steam Load
- Medium Steam Load
- Low Steam Load
- X,XXX PPH Estimated Building Steam Load
- New Main Line Isolation Valve
- New S/C lines in Bldgs
- New buried S/C lines

NOTES:

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STEAM LINES
IDAHO STATE UNIVERSITY
ADDRESS

IDAHO STATE UNIVERSITY

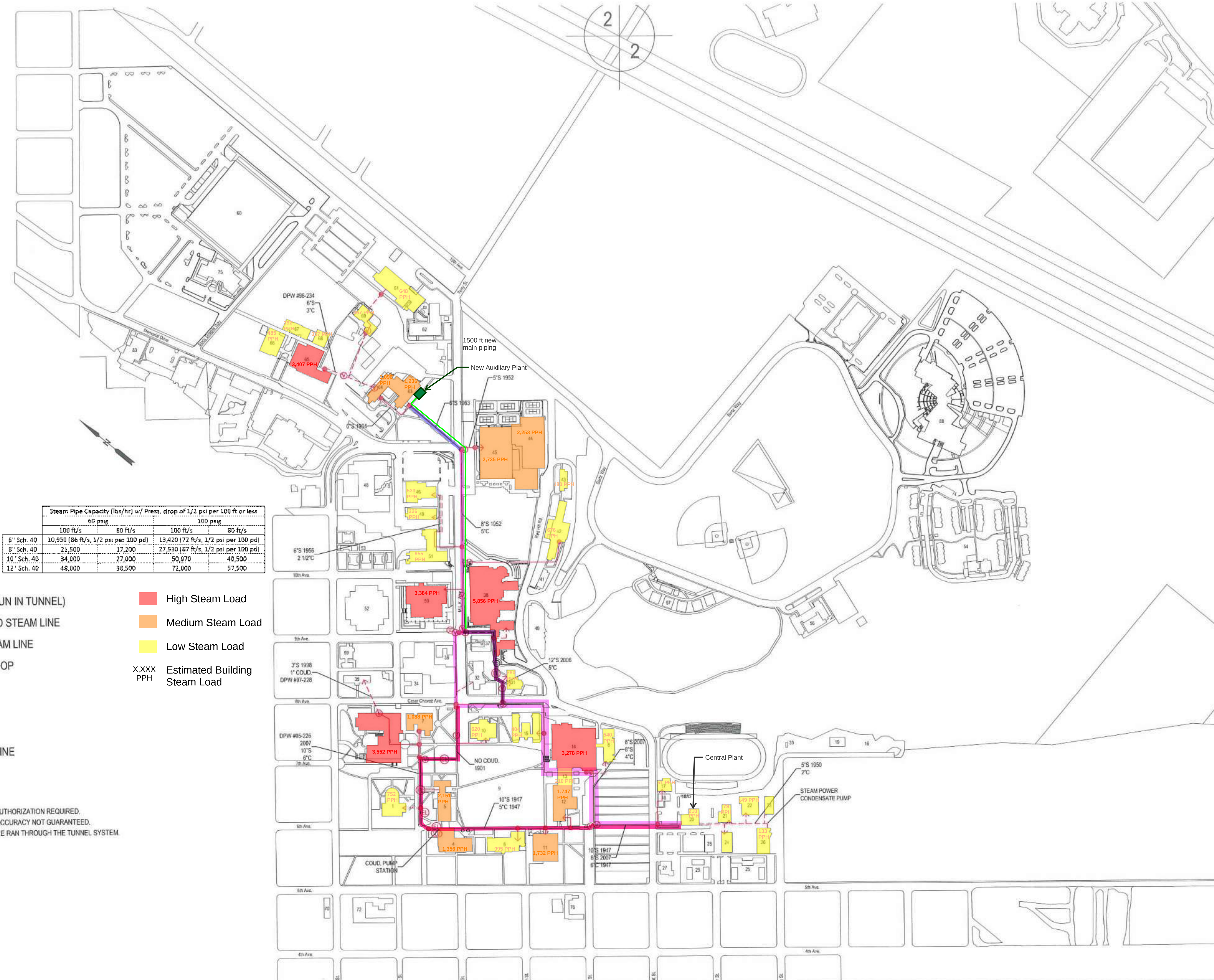
BUILDING NUMBER

LEVEL

DISCIPLINE
Civil

DRAWING SCALE
NONE

UPDATE DATE
08/24/2011



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STEAM LINE (RUN IN TUNNEL)
DIRECT BURIED STEAM LINE
ENCASED STEAM LINE
EL EXPANSION LOOP
V VALVE
SERVICE
S STEAM LINE
C CONDENSER LINE

High Steam Load
Medium Steam Load
Low Steam Load
X,XXX PPH Estimated Building Steam Load

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STEAM LINES
IDAHO STATE UNIVERSITY
ADDRESS

IDAHO STATE UNIVERSITY

BUILDING NUMBER	---
LEVEL	---
DISCIPLINE	Civil
DRAWING SCALE	NONE
UPDATE DATE	08/24/2011

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STEAM LINE (RUN IN TUNNEL)
DIRECT BURIED STEAM LINE
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High Steam Load
Medium Steam Load
Low Steam Load
X,XXX PPH Estimated Building Steam Load

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STEAM LINES
IDAHO STATE UNIVERSITY
ADDRESS

IDAHO STATE UNIVERSITY

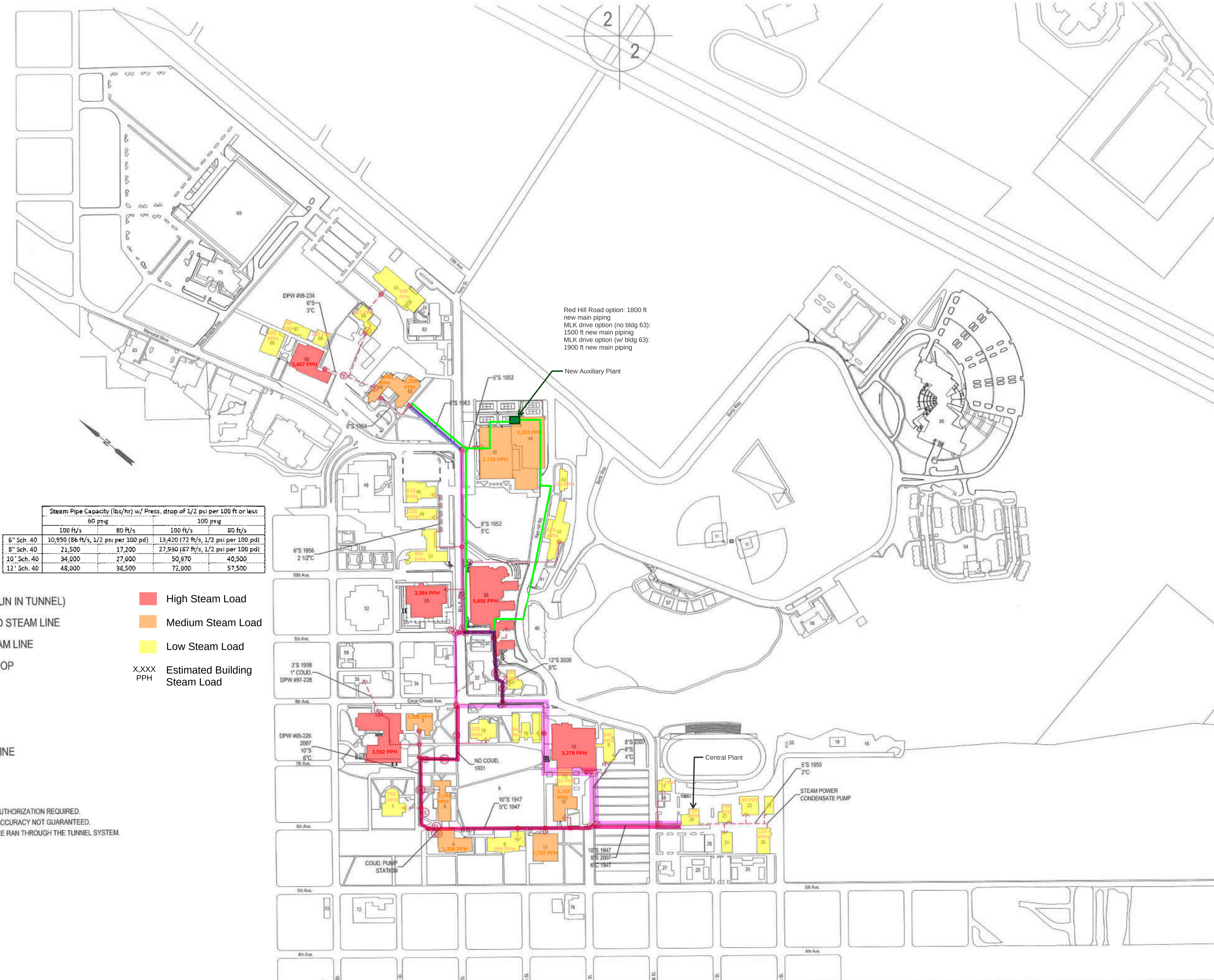
BUILDING NUMBER

LEVEL

DISCIPLINE
Civil

DRAWING SCALE
NONE

UPDATE DATE
08/24/2011



	Steam Pipe Capacity (lbs/hr) w/ Press. drop of 1/2 psi per 100 ft or less			
	60 psig		100 psig	
	100 ft/s	80 ft/s	100 ft/s	80 ft/s
6" Sch. 40	10,950 (86 ft/s, 1/2 psi per 100 pd)		13,420 (72 ft/s, 1/2 psi per 100 pd)	
8" Sch. 40	21,500	17,200	27,930 (87 ft/s, 1/2 psi per 100 pd)	
10" Sch. 40	34,000	27,000	50,970	40,500
12" Sch. 40	48,000	38,500	72,000	57,500

STEAM LINE (RUN IN TUNNEL)
DIRECT BURIED STEAM LINE
ENCASED STEAM LINE
EL EXPANSION LOOP
V VALVE
SERVICE
S STEAM LINE
C CONDENSER LINE

High Steam Load
Medium Steam Load
Low Steam Load
X,XXX PPH Estimated Building Steam Load

NOTES:

1. FOR ISU USE ONLY, PROPER AUTHORIZATION REQUIRED.
2. SCHEMATIC DRAWING ONLY, ACCURACY NOT GUARANTEED.
3. MAJORITY OF STEAM LINES ARE RAN THROUGH THE TUNNEL SYSTEM.

FACILITIES SERVICES
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(208) 282-4086 OFFICE
(208) 282-4618 FAX

STEAM LINES
IDAHO STATE UNIVERSITY
ADDRESS

IDAHO STATE UNIVERSITY

BUILDING NUMBER

LEVEL

DISCIPLINE
Civil

DRAWING SCALE
NONE

UPDATE DATE
08/24/2011

- STEAM LINE (RUN IN TUNNEL)
- DIRECT BURIED STEAM LINE
- ENCASED STEAM LINE
- EL EXPANSION LOOP
- V VALVE
- SERVICE
- S STEAM LINE
- C CONDENSER LINE

- High Heating Load
- Medium Heating Load
- Low Heating Load
- X,XXX MBH — Estimated Building Heat Load

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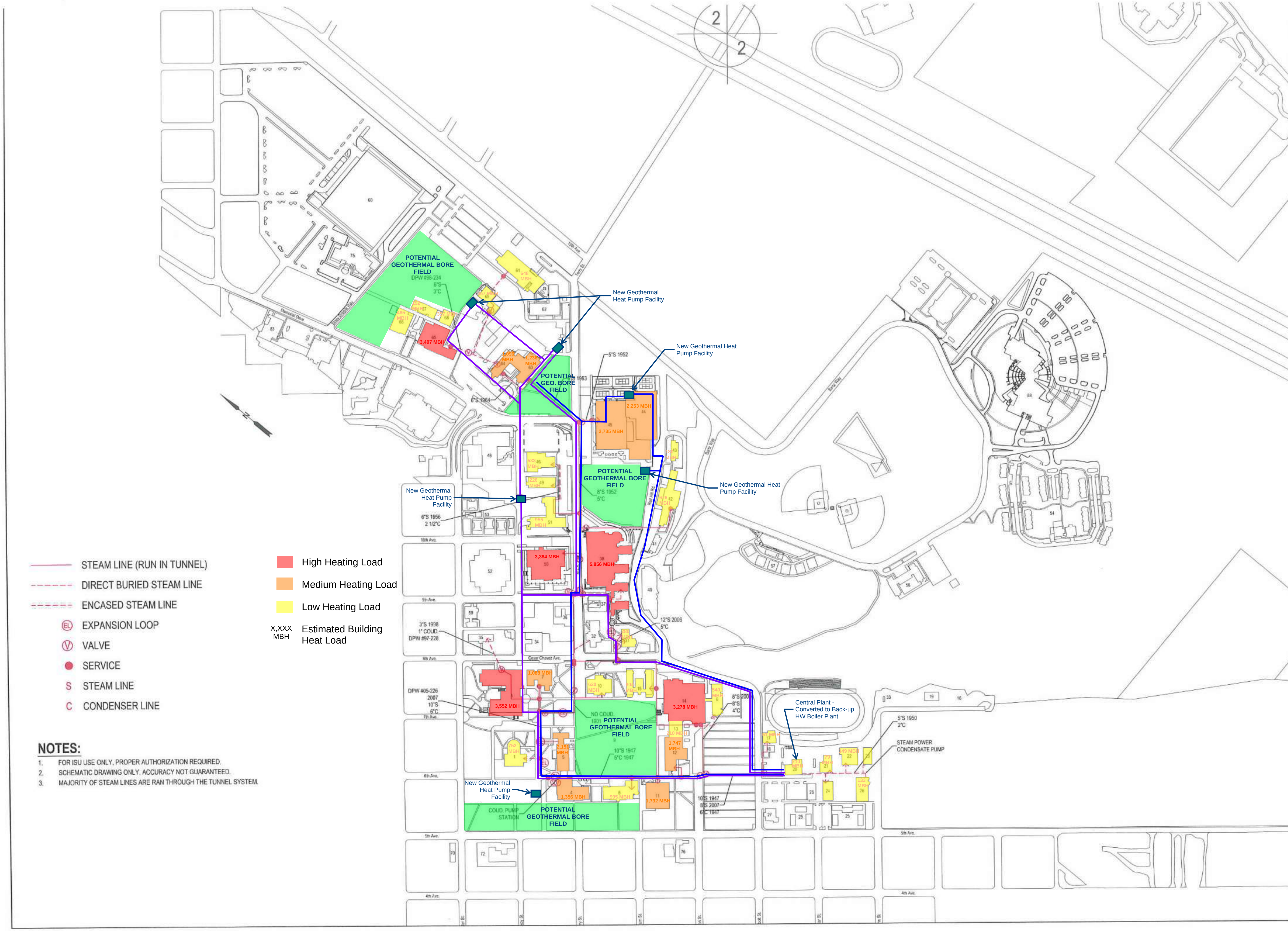

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IDAHO STATE UNIVERSITY

BUILDING NUMBER

LEVEL

DISCIPLINE

Civil

DRAWING SCALE

NONE

UPDATE DATE

08/24/2011

August 23, 2021

Paul D. Rasmussen
Idaho State University
638 East Dunn., Stop 8137
Pocatello, Idaho 83209

Re: ISU Pool Investigation
Martin/Martin Wyoming, Inc. Project No.: 21-047

Mr. Rasmussen,

Martin/Martin Wyoming visited the Idaho State University pool on Friday August 6, 2021 to observe and investigate the condition of the existing pool structure located in Reed Field House on the Idaho State University campus in Pocatello, Idaho. MMWyo was initially contacted by ISU due to structural concerns regarding the integrity of the existing pool, the pool was leaking a substantial amount of water daily which gave rise to the concern for the pool structure.

Pool Structure

The existing pool structure is a cast-in-place concrete structure which is believed to have been constructed in the 1950's. The pool consists of a concrete slab-on-grade pool floor, concrete side walls and an elevated concrete slab pool deck. The pool deck slab surrounds the entire perimeter of the pool, the deck slab spans between the adjacent building wall and the pool side wall. The space below the pool deck on the west side contains the pool mechanical equipment room. The north, south and east sides are crawlspace with soil on grade at the floor of the crawlspace between the pool wall and building wall.

Investigation

The investigation consisted of the following:

- Visual observation of the drained pool from the natatorium as well as the mechanical room on the west side of the pool and the crawlspace to the north, east and south sides of the pool.
- Sounding of the pool walls from the crawlspace and mechanical room to the extent possible, access was limited in some areas due to pool equipment and soil adjacent to and up against the side of the pool wall in the crawlspace.
- Borescope review through approximately (8) ¾" diameter holes which were drilled in the pool floor slab. A visual inspection was performed with a borescope, and a rod was also used to probe the existing subgrade.
- Review of available existing pool drawings; existing drawings consisted of three structural sections on a single sheet and two sheets comprising a partial pool plumbing plan.
- Discussion with maintenance staff and review of the available pool maintenance log which included the amount of water added to the pool each day since late June 2021.

Martin/Martin Wyoming, Inc.
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Avon, CO | Fort Collins, CO | Bay Area, CA | Northwest Arkansas | Albuquerque, NM

Observations

The overall condition of the pool is consistent with a concrete structure of this age. Temperature and shrinkage cracking was observed in the pool side walls from the mechanical room and crawlspace. Cracking was also observed in the pool side walls at the change in floor slope from the shallow end to the deep end. When the walls were sounded, areas of deterioration were observed, and the approximate extent of these areas is shown on sheets S-100 and S-101. A severe case of deterioration can be observed in photo 1. Additional smaller areas of deterioration were observed around side wall lights and at wall crack locations which had a buildup of what is most likely calcium. This buildup indicates the location as been leaking for an extended period of time.

A substantial crack was observed in the pool floor which extended from the shallow end on the west to approximately the drain at the deep end near the east end of the pool. Several holes were made in the pool floor at the time of the site investigation. A rod was used to probe the subgrade and a borescope was used to look for voids below the pool slab-on-grade floor. Soft/moist material was observed in several of the hole locations. A void was observed under the crack noted above at approximately the mid-point of the pool in the east-west direction, see photo 2. A potential void was also observed in the shallow end to the south of the crack.

The soil in the crawlspace was moist at the time of the site observation, which we believe occurred approximately two weeks after pool was drained. The soil in the crawlspace showed signs of erosion; evidence that the volume of moving water has transported the subgrade soil, see photos 3 and 4. A thin layer of soil and miscellaneous build-up of soil in the mechanical room was further evidence that erosion has taken place, see photo 5.

In discussions with ISU maintenance personnel, we understand that the volume of water added to the pool to maintain the correct water depth has recently significantly increased. The volume of water added to the pool in the last maintenance log entry was 9136 gallons/day. A rough approximation of water evaporating and lost during pool use via exiting occupants is approximately 1000 to 2000 gallons per day based on discussions with Tom Anderson of Water Design Inc. Per discussions with maintenance personnel, we understand that approximately 2500 to 3000 gallons of water has been required daily for at least several months.

ISU personal has also noted that the southwest corner of the pool settled approximately 1.5” when filled. We understand that this is visible via the elevation of the pool gutter. While cracks in the pool side wall were observed it is difficult to attribute a specific crack or group of cracks to settlement of one corner of the pool structure. The pool structure may remain rigid when this settlement occurs. MMWyo has not had an opportunity to observe the pool when filled.

Recommendations/Conclusions

The general condition of a large portion of the pool concrete viewed appeared to be sound. However, deterioration was observed in multiple areas. The deterioration which was observed along the base of the deep end adjacent to the mechanical room is of particular concern due to the length of wall impacted along with forces imposed by the water at the deep end of the pool. MMWyo recommends repair of the deteriorated areas of concrete along with replacement of reinforcing which has deteriorated.

A void was observed under the pool floor slab with evidence of erosion via substantial water infiltration below and around the pool. Based on the existing drawings, the pool floor slab was designed to have continuous support from the subgrade and was not intended to span over voids or soft spots in the subgrade. Furthermore, due to evidence of water moving under and around the pool, the subgrade below the pool structural walls may be compromised. A compromised subgrade may be contributing to the settlement of the pool when filled. MMWyo recommends mud-jacking or grouting under the entire pool slab as needed as the extent of the subgrade erosion cannot be accurately mapped. We also recommend repairing/filling the crack in the slab on grade. Additional recommendations include excavation at discrete intervals around the perimeter of the pool to observe the condition of the subgrade below the pool footing. This exploratory excavation to observe the subgrade should occur prior to slab grouting or repair.

The recommendations provided above are conceptual in nature and are intended to provide the University an overview of the structural repairs which are anticipated based on the observations and investigation performed. MMWyo recommends a structural and geotechnical engineer visit the site during the exploratory excavation to observe the condition of the pool which was not visible during the observation. Additional deterioration of the pool side wall may be observed during the excavation to observe the foundation subgrade.

The repairs noted above are based on, and limited to, the investigation and observations performed. Additional repairs may be warranted if damaged or deteriorated concrete is observed moving forward. The conceptual repairs noted above are intended to provide structural integrity and are not intended to address water leaking from the pool. It is critical that the leak be addressed as additional erosion may lead to failure of the pool slab, walls or deck. MMWyo recommends that a pool consultant be engaged to provide repair details and potentially liner options to address the pool leaking.

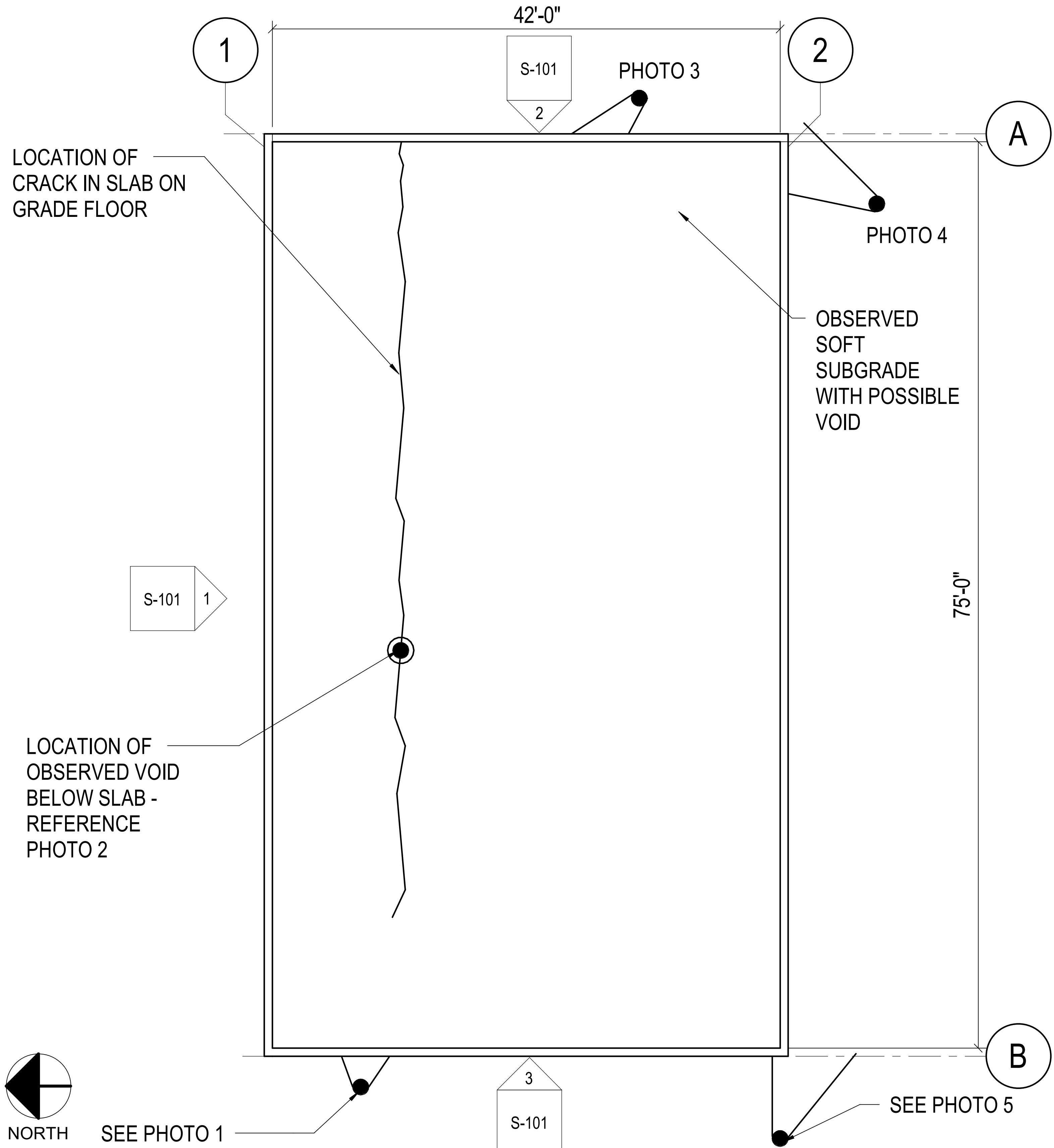
The University may wish to perform additional investigation prior to making the pool repairs. Additional testing which would lead to a more thorough evaluation of the pool structure would include concrete strength tests performed on cores taken from the pool and petrographic analysis of the pool concrete. MMWyo is available to provide repair drawings or consult on repair or testing options.

Sincerely,

Garth Scholl
Principal

Patrick McManus PE
Principal

Document1



ISU POOL INVESTIGATION

MARTIN/MARTIN WYOMING

4020 LARAMIE STREET | CHEYENNE, WYOMING | 82001
307.637.8422 MMWYO.COM

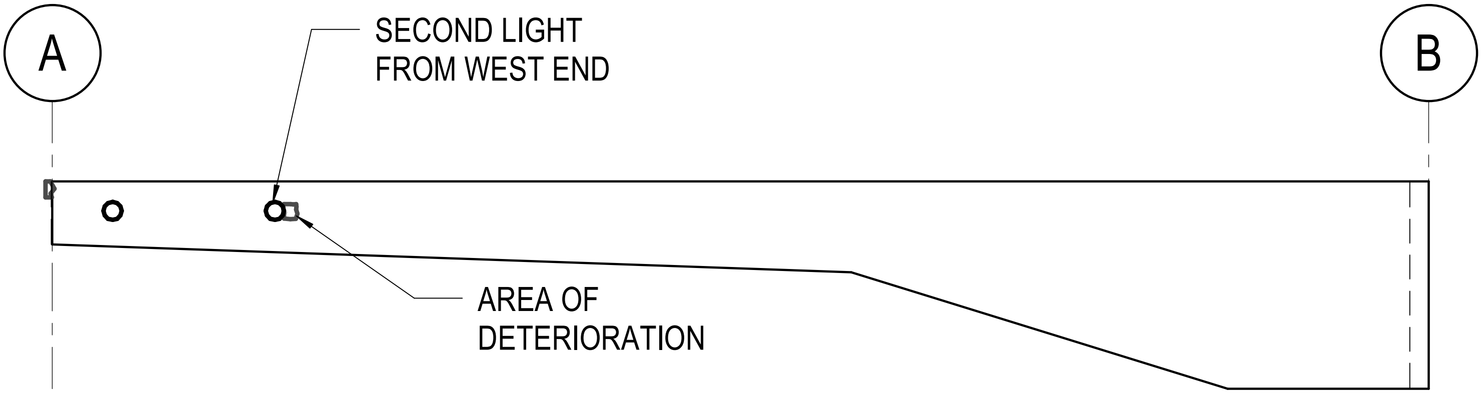
DETAIL TITLE:
ISU POOL - FIGURE 1

DETAIL NO:
S-100

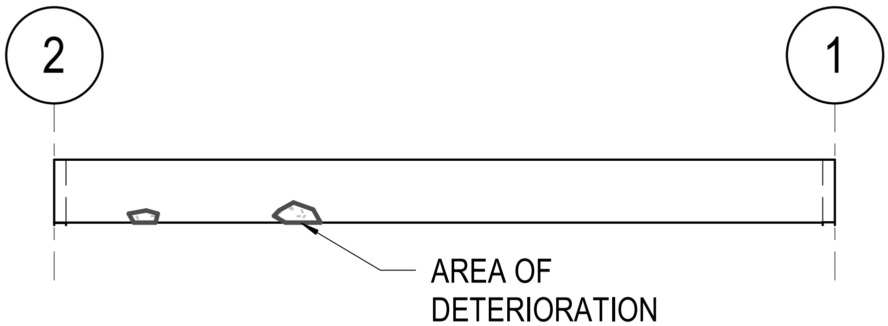
PROJECT NUMBER: 21.047

DWG REF:

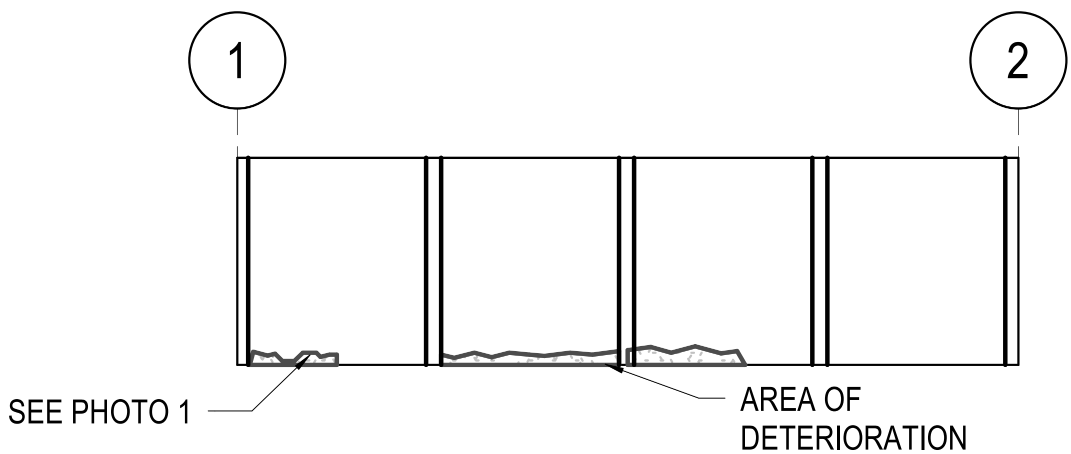
DATE: 08/23/21



1 NO SCALE **NORTH ELEVATION**



2 NO SCALE **EAST ELEVATION**



3 NO SCALE **WEST ELEVATION**

ISU POOL INVESTIGATION

MARTIN/MARTIN WYOMING 4020 LARAMIE STREET | CHEYENNE, WYOMING | 82001 307.637.8422 MMWYO.COM	DETAIL TITLE: ISU POOL - FIGURE 1	DETAIL NO: S-101
PROJECT NUMBER: 21.047	DWG REF:	DATE: 08/23/21

Photo 1 – West wall of pool

Photo showing area of concrete and reinforcing deteriotation resulting in a section of spalled concrete and loss of reinforcing cross section. Location is at the bottom of the wall at the deep end of the pool in the mechanical room.

Photo 2 – From Boroscope

Photo from borescope, voids were observed below the pool floor slab, location was directly in-line with the crack location noted.

Photo 3 – Soil in crawl space

Photo of crawlspace on the east side of the pool (shallow end), evidence of moving water and erosion in crawlspace area.

Photo 4 – Soil in crawlspace

Photo of crawlspace on the southeast corner of the pool (shallow end), evidence of moving water and erosion in crawlspace area.

Photo 5 – Soil in mechanical room from crawlspace

Photo of mechanical room entrance into crawlspace on south side, soil in mechanical room erroded from crawlspace.

Water Design Inc.
6740 S 1300 E, Ste 110, Salt Lake City, Utah 84121 phone: (801) 261-4009 fax: (801) 261-4069

September 23, 2021

Mr. Paul D. Rasmussen
Idaho State University
Facilities Services
921 South 8th Avenue, Stop 8137
Pocatello, Idaho 83209

Re: Idaho State University - Reed Gym & Student Recreation Center Swimming Pool Leak Assessment Study

Dear Mr. Rasmussen,

Water Design, Inc. was asked to visit the above referenced Idaho State University (ISU) Swimming Pool in Pocatello, Idaho to observe and assess the swimming pool leaking. Water Design visited the pool on August 17, 2021. Martin and Martin had previously visited the site on August 6, 2021 to assess the leaking and the structural condition of the swimming pool. They presented a report dated August 23, 2021 addressing the known structural problems with the pool and provided structural assessment and repair options and recommendations. Water Design's study and report is intended to supplement the Martin and Martin report to address primarily options moving forward for pool waterproofing.

<u>Recent History and Scope of this report</u>:
ISU reported that the pool had suddenly begun to leak excessively and some cracking was observed in the pool finish. A site visit was requested and authorized by ISU to perform the following scope of services;

1. Travel to/from Pocatello, Idaho to perform a site observation visit to gather the necessary information required in order to provide potential waterproofing repair options and recommendations.
2. Research viable waterproofing repair options based on existing conditions and explore multiple methods for repair.
3. Provide a written report outlining the known existing conditions and provide viable waterproofing repair solutions.

Water Design will utilize best practices along with The Idaho Construction and Operation of Public Swimming Pool Regulations (the code) as a reference for this report. The findings and recommendations formulated from my site visit will be presented in this report as follows:

Summary of Existing Pool Systems and Conditions:

The above referenced facility contains a rectangular shaped lap pool that measures 42 feet by 25 yard (75 feet) long and contains six (6) marked lap lanes. The depths range from 3’-6” water depth in the shallowest areas to 10’ water depths in the deeper area of the pool. There are six (6) starting blocks located along the deep end wall at each swim lane. We understand that the pool was originally built in the 1950s (approximately 70 years old).

The pool was originally constructed of cast-in-place concrete and a waterproof tile finish. The original waterproofing design appears to have consisted of utilizing high strength concrete, integral water stops, possibly a waterproof membrane applied to the concrete pool floor (can’t see evidence of this however), and water-resistant tiling materials and finishes. The existing pool is still utilizing the original designed waterproofing systems.

The existing pool utilizes a small scum gutter (3” wide by 4” deep) to provide overflow/surge capacity and to allow for pool skimming. The overflow system consists of a small perimeter trough built into the pool wall at water level to allow pool water to skim over the gutter edge and into the trough. Water in the trough would flow to a number of small drain grills where it would ultimately flow to the pool equipment room where it would be pumped, filtered, heated, treated, and returned to the pool via a number of supply inlets located near the bottom of the vertical wall and penetrating through the pool wall. ISU reports that the pool has subsided by 1.0” to 1.5” on one end and when filled with water is no longer providing a level gutter rim for skimming. This type of gutter system was not originally designed to handle 100% of the circulation flow rate and is not capable of full skimming per current codes and standards. The design relied on lower levels of surface skimming and did not provide for remote surge capacity. The surge would be handled by flooding the gutter system and water levels fluctuating within the pool during use. This is no longer an acceptable way of designing a gutter pool per industry standards and codes.

The existing pool appears to still be utilizing the original metallic piping at the gutter penetrations, return inlet penetrations through the walls, and possibly the main drain pipes in the pool floor where they are encased in concrete. These metallic pipes have already surpassed their life expectancy and should be expected to begin failing and leaking more and more as time goes on. All of the easily accessible piping in the system appears to have been changed from original metallic piping to PVC type piping at some point during the life of the pool. PVC piping is what is commonly used in the swimming pool industry today.

The existing pool utilizes “dry niche” lights which are accessible from behind the pool wall in the pipe chase (tunnel) that surrounds the pool structure.

Pool Picture facing East

Reported Leaking, Field Observations, and Conclusions:

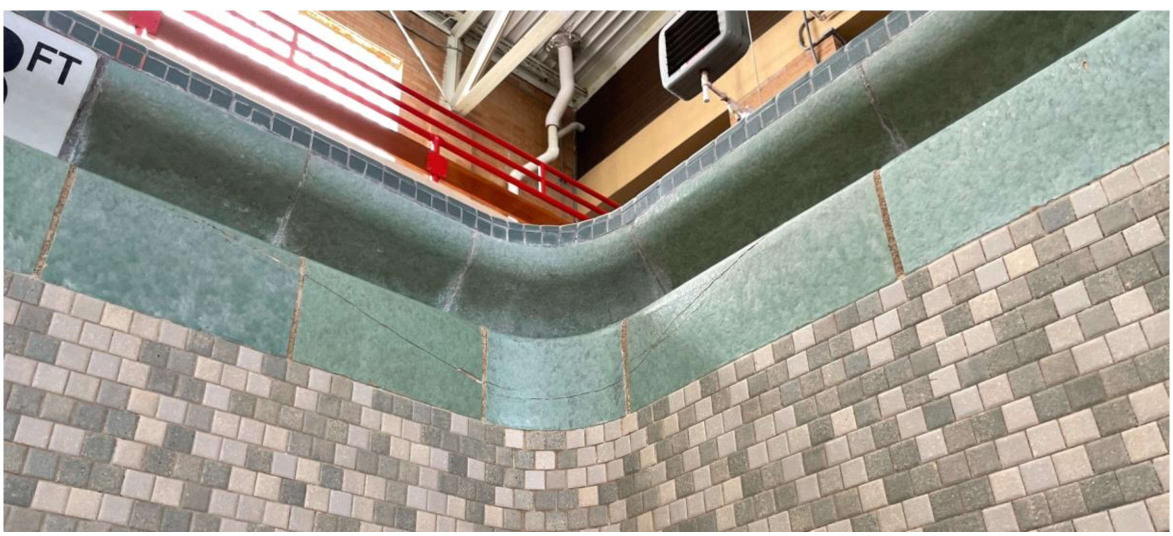
ISU reported that the pool began leaking recently and that the leaking had suddenly increased after a routine draining and filling of the pool for maintenance and repairs. Previous water loss from the pool was ~2,000-3,000 gallons per day and this had increased to ~8,000-9,000 gallons per day after the pool was filled up with water again. Also, a noticeable crack was observed running longitudinal along the length of the pool floor and other parts of the pool walls as well.

During Water Design's site observation visit, a large crack was observed in the pool floor starting at the shallow end wall (north east wall) and extending down the pool length to the deep end. The crack jogs slightly at the transition in floor slope (at break line) but extend all the way to the deep end.

Additional cracks were observed on the vertical walls from inside the pool as follows:

Shallow End Wall (NE Wall): 2 vertical cracks observed.
Side Wall (NW Wall): 10 vertical cracks observed.
Deep End Wall (SW Wall): 4 vertical cracks observed.
Side Wall (SE Wall): 12 vertical cracks observed.

Examples of observed cracks



Based on the pool having subsided (tilted) and the fact that this pool's original waterproofing system is at (or past) its life expectancy. We would expect that these types of problems will be recurring and become more frequent as time goes on without instigating a repair and renovation plan.

<u>Options for Repair/Renovation</u>:

Along with our own site observations, excerpts from the original design plans and Martin and Martin's report dated August 23, 2021 were received from ISU, and studied to help inform the recommendations in this report. Water Design sees and recommends that ISU consider a minimum four (4) different levels of repair/renovation options depending on the repair solution's desired longevity. The four (4) options are presented in order of expected longevity from shortest to longest as follows (although I comment on the cost of each option relative to each other, estimating the actual cost of each option is beyond the scope of this report. Cost estimating would typically be done separately and/or would be done as part of a renovation design effort once a general direction for design has been selected by the University for further consideration):

Option #1 -Short Term Length Repair Option -Repair/Patch existing leak points

Option #1 is considered a short-term repair option and would involve repairing and patching any known or suspected leak points in the pool. This type of repair would require localized removal of tile pool finish and repairing and sealing of all known cracks utilizing a semi-flexible crack repair solution. Once any suspected cracks or leak points are repaired, a flexible waterproof membrane would be applied to the concrete over the patches and the tile pool finish would be replaced/patched to match the rest of the pool tile. **This option DOES NOT extend the life of the pool** since it is only dealing with problems as they arise and does not provide preventative measures for future cracking/leaking. **This repair/patch would extend the waterproofing life of the patched area only an estimated 2 to 5 years (assumes pool structural repairs are made per the Martin and Martin report)**. The estimated cost of this type of repair is $140 to $200 per lineal foot (including tile replacement). If we assume that there is approximately 300 feet of total crack length, this would cost an estimated $42,000 to $60,000** to repair.

Pros to Option #1

- Least time of all options to accomplish repairs. Requires a few weeks per repair once a contractor is selected and lined up to do the work.
- Least expensive option
- Maintains tiled pool look that you currently have (tiled pools considered high end aesthetics).

Cons to Option #1

- Short term repair (Does not allow for a long-term solution).
- Temporary solution only. We would expect a pool of this age will continue to reveal leaking problems in different locations unless a permanent solution with preventative measures is provided. Theoretically the pool could start leaking the very next day in a different spot.
- This can create a situation where the University feels like they are chasing their own tails by doing repetitive repairs on a regular basis (increasing total down time).
- This solution will create uneven aesthetics in the pool finish where patching is needed in the pool tile (new tile against old tile will be visible and very noticeable).
- Does not address existing metallic piping deficiencies.
- Does not address existing gutter and/or surge tank deficiencies.

**estimated budget prices need to be verified with a qualified waterproofing and tile contractor

Option #2 –Short to Mid-Term Length Repair Option -Install Flexible membrane liner over existing pool finish and gutter system.

Option #2 is considered a short to mid-term length repair option and would involve installing a loose flexible PVC membrane over the entire pool (both vertical and horizontal planes). This would require special protective layer between the flexible membrane and existing tile. This solution anticipates that the membrane would be installed up to the deck and throughout the pool gutter. This type of system comes with up to a 10-year waterproofing warranty and **would extend the life of the pool waterproofing life by an estimated 10 to 15 years**. This option would need to anticipate that all buried and encased metal main drain and return piping would be replaced (metallic gutter piping would remain due to cost and difficulty accessing piping). The estimated cost of construction for Option #2 would be in the range of $175,000 to $250,000**.

Pros to Option #2

- Short to Mid-term length repair solution (longer than Option #1).
- This option provides a preventative solution against future leaking due to pool cracking due to flexible nature of membrane finish.
- Middle level price range for repairs.

Cons to Option #2

- The flexible PVC membrane over the entire pool typically provides a less refined/messier look than the other repair options presented herein. The exposed flexible gutter membrane provides an especially noticeable reduction in aesthetics as compared to other systems.
- Flexible membrane is susceptible to wrinkling (especially on the vertical plane) and relies on a compression seal for waterproofing which is susceptible to leaks in future.
- Requires more time to accomplish repairs (as compared to option #1). An estimated time of repair of a couple of months once a contractor is lined up.
- Substantially more expensive than Option #1.
- Does not address existing gutter design and/or surge tank deficiencies.

**estimated budget prices need to be verified with a qualified installer. Flexible Liner System manufacturers we are familiar with include: Natare Corporation and RenoSys.

***See Appendix Option #2 images at end of report for sample construction and post construction aesthetics.

Option #3 –Mid-Term Length Repair Option -Re-Waterproof and Re-Tile entire existing pool interior.

Option #3 is considered a mid-term length repair option and would involve completely removing the existing tile finish, repairing and sealing the existing structure and cracks (per Martin and Martin direction), installing a liquid applied elastomeric waterproof membrane over entire pool shell, and installing new tile finish over the new waterproofing membrane. This solution typically comes with up to a 5-year waterproofing warranty and **would extend the life of the pool shell by an estimated 5 to 15 years**. This option would anticipate that all buried or encased metal main drain and other piping would be replaced. The estimated cost of construction for Option #3 would be in the range of $450,000 to $550,000**.

Pros to Option #3

- Mid-term length repair solution.
- Maintains tiled pool look that currently exists (historic and high-end aesthetics)
- This option provided a mitigating solution against future leaking due to pool cracking due to liquid applied elastomeric waterproofing barrier.

Cons to Option #3

- Increased time to accomplish repairs. Requires two to three months to complete repairs once a contractor is engaged.
- Substantially more expensive than Option #1 and Option #2 (higher end cost range).
- Future or widening of cracks in the pool structure could exceed the product limits and compromise waterproofing system and reveal aesthetic surface cracking and potential leaking (could be patch repaired as needed).
- Does not address existing industry standard and code deficiencies.
- Does not address existing gutter and/or surge tank deficiencies.

**estimated budget prices need to be verified with a qualified waterproofing and tile contractor

Option #4 –Long Term Repair Option -Install PVC clad Stainless Steel Pool System.

Option #4 is considered a long-term repair option and would allow for full gutter re-levelling and improvements and renovations without increased risk of future leaking. This system would also allow ISU to keep the existing pool finish in place (with little to no prep work) and install a permanently fixed and rigid PVC clad stainless steel wall system over the existing pool structure. A new PVC or tile gutter lip would be incorporated to bring existing pool up to current design standards. The horizontal floor of the pool would have a flexible PVC membrane installed that adheres and seals to the PVC coated stainless steel wall system. This solution comes with up to a 10-15 year waterproofing warranty and **would extend the life of the pool shell by an estimated 20 to 30 years**. This option would also anticipate that all buried or encased metal main drain and other piping would be fully replaced. The estimated cost of construction for Option #4 (including full gutter replacement) would be in the range of $600,000 to $750,000**.

Pros to Option #4

- Longest term repair solution (up to double longevity of that of Option #2 & 3).
- Provides a clean/neat look utilizing PVC or ceramic tile for the gutter and trim tiles. It also provides clean/neat looking PVC clad stainless steel wall system that is fixed to the existing structure (high end aesthetics).
- This option provided a preventative solution against future leaking due to pool cracking.
- This system allows for easier addressing of gutter and surge deficiencies due to the full replacement of the gutter system.
- This system allows for replacement of the “dry niche” underwater lights to traditional modern “wet niche” underwater pool lights.
- This system allows for easier addressing of other code deficiencies (less expensive than other options to bring other items up to standards while doing work).

Cons to Option #4

- Increased time to accomplish repairs. Down time of a six months or even more to complete the renovation and repairs (more design and fabrication of system required).
- More expensive than Option #1, Option #2, and Option #3 (highest end of cost range).

**estimated budget prices need to be verified with a qualified installer. PVC clad Stainless Steel Pool System manufacturer we are familiar with include: Myrtha Pools.

***See Appendix Option #4 images at end of report for sample construction and post construction aesthetics.

Conclusion:

Although Option #4 will likely be the most expensive and require the most construction time of the options presented, Water Design recommends that the University consider planning for this long-term solution. We believe it will likely provide the best overall value when considering the warranty and the extended pool life it provides. This type of system provides a very high-end pool system (both functionally and aesthetically) with the longest warranty in the industry. It will allow for an extended pool life of up to 30 years (and even more length of life expected in most cases). This is similar to the longevity that is expected and experienced in new pool design and construction today. I recommend only considering options #1 and #2 as short term or temporary solutions until a more permanent long-term solution can be developed and financed. Option #3 is not a preferred option since it still comes with relatively higher expenses and risk of future cracking and leaking. Option #3 would also be very difficult to bring the gutter and other pool systems to current codes and standards.

The above recommendations are the professional opinion of Water Design, Inc. and are based only upon our site visit, research, and observations. They are intended to address the pool cracking, leaking, and potential waterproofing repairs as they existed at the time of our visit. All other potential scope items such as redoing the pool equipment, filters, heating, chemical treatment, upgrading code items, etc in the equipment room is not included in this report. The observations in this report should not be relied upon as all-inclusive since they deal primarily with the leaking and waterproofing issue and gutter and surge related items that are related and pose a concern for the pool. Prior to repair, construction, and/or implementation of these recommendations, the complete pool systems shall be engineered and designed for bid. Construction documents stamped by a qualified engineer shall be submitted to the local health and building departments for their approval.

Sincerely,

Thomas P. Anderson
Water Design, Inc.

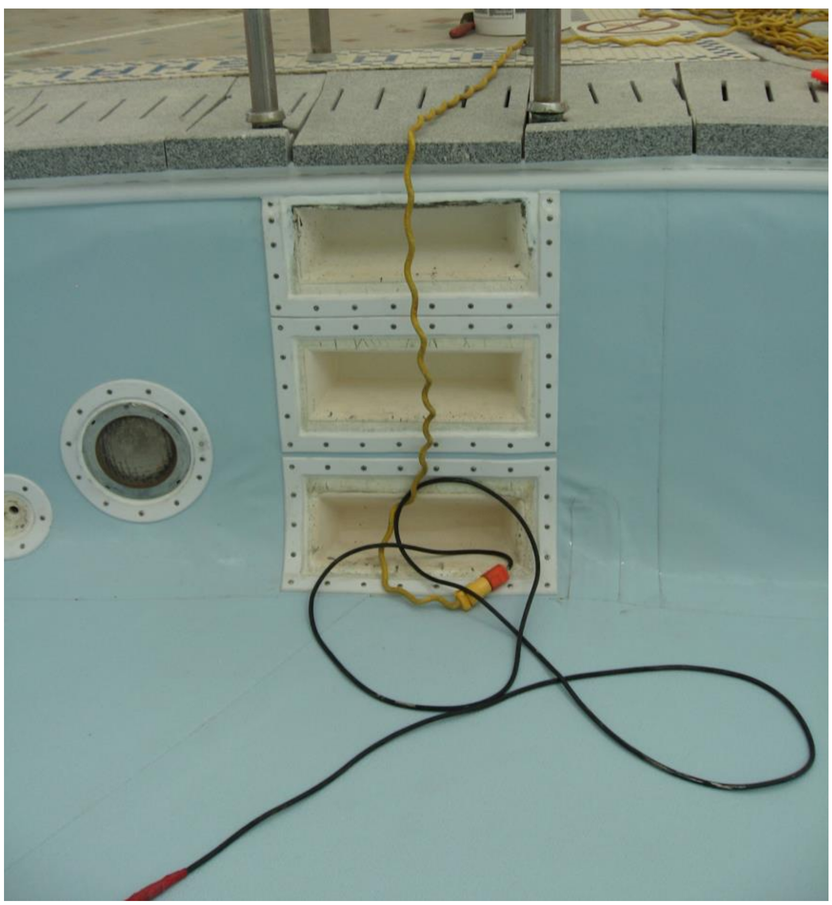
END OF REPORT

APPENDIX

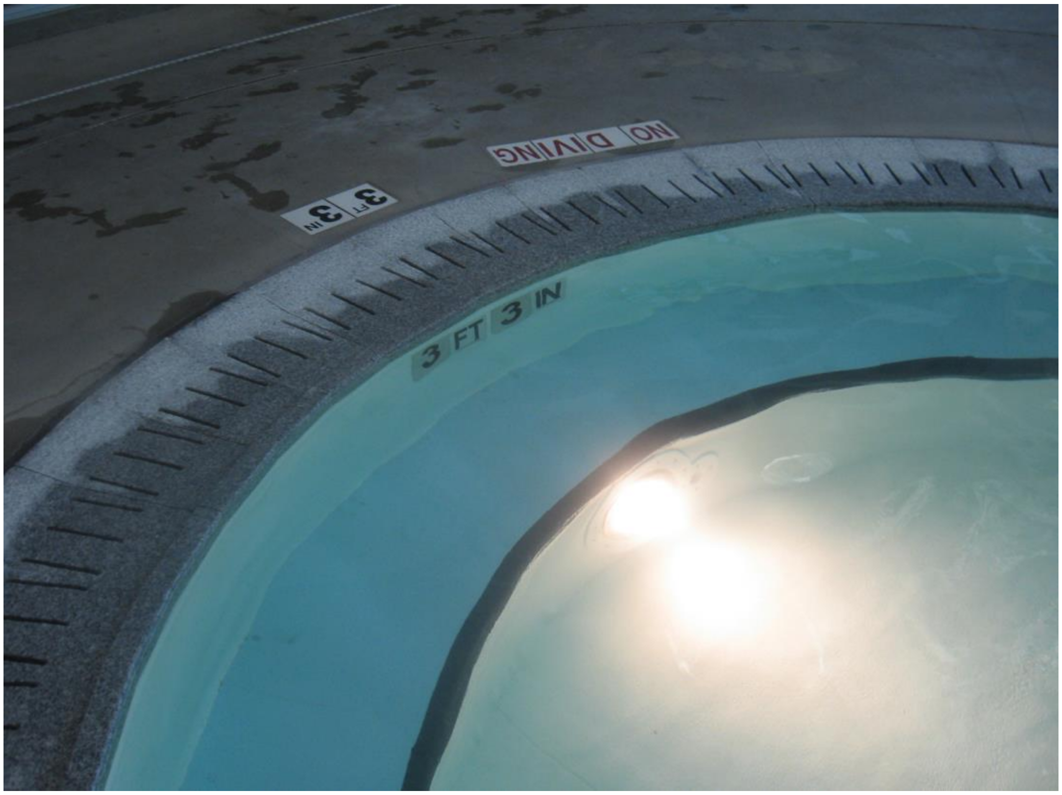
OPTION #2 -FLEXIBLE MEMBRANE LINER SYSTEM EXAMPLE IMAGES

CONSTRUCTION IMAGES


FT 6 IN
3 FT 7 IN



FINISHED POOL IMAGES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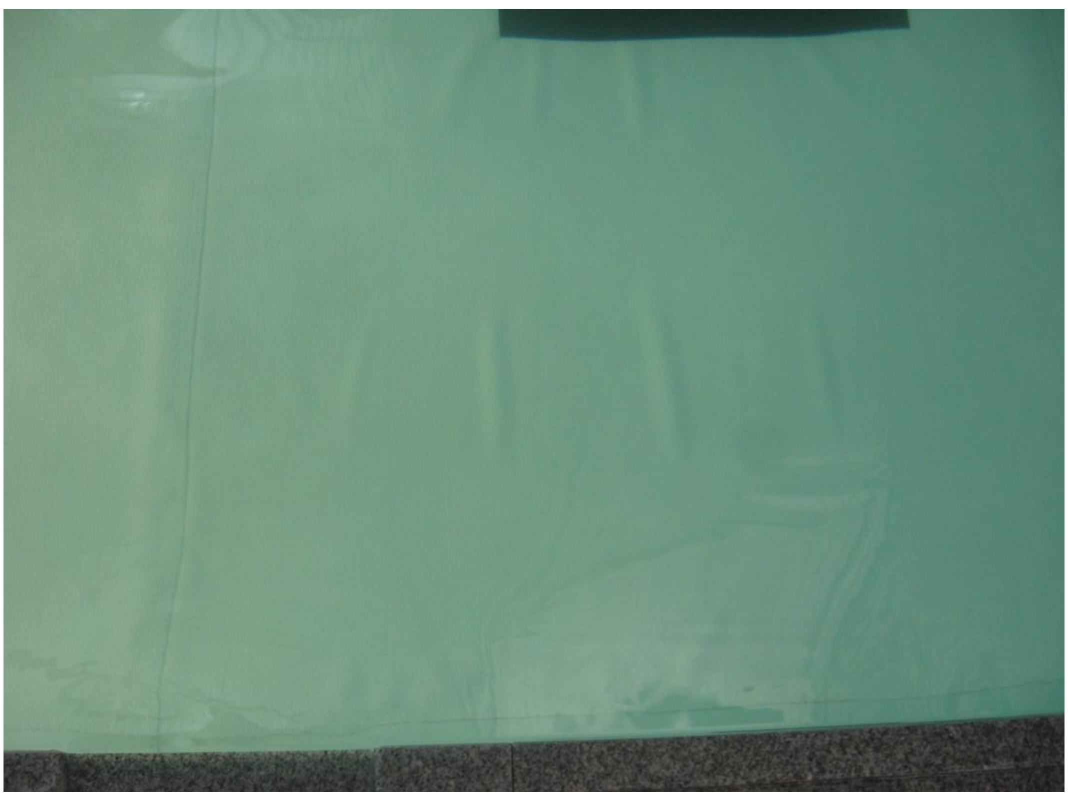
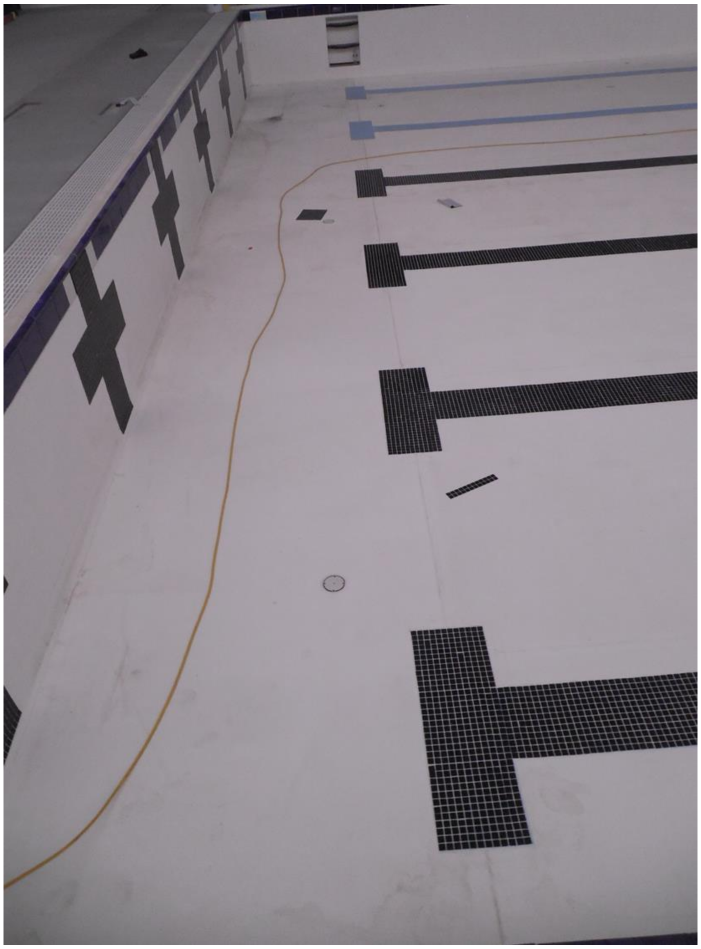
3 FT 3 IN
3 FT 3 IN

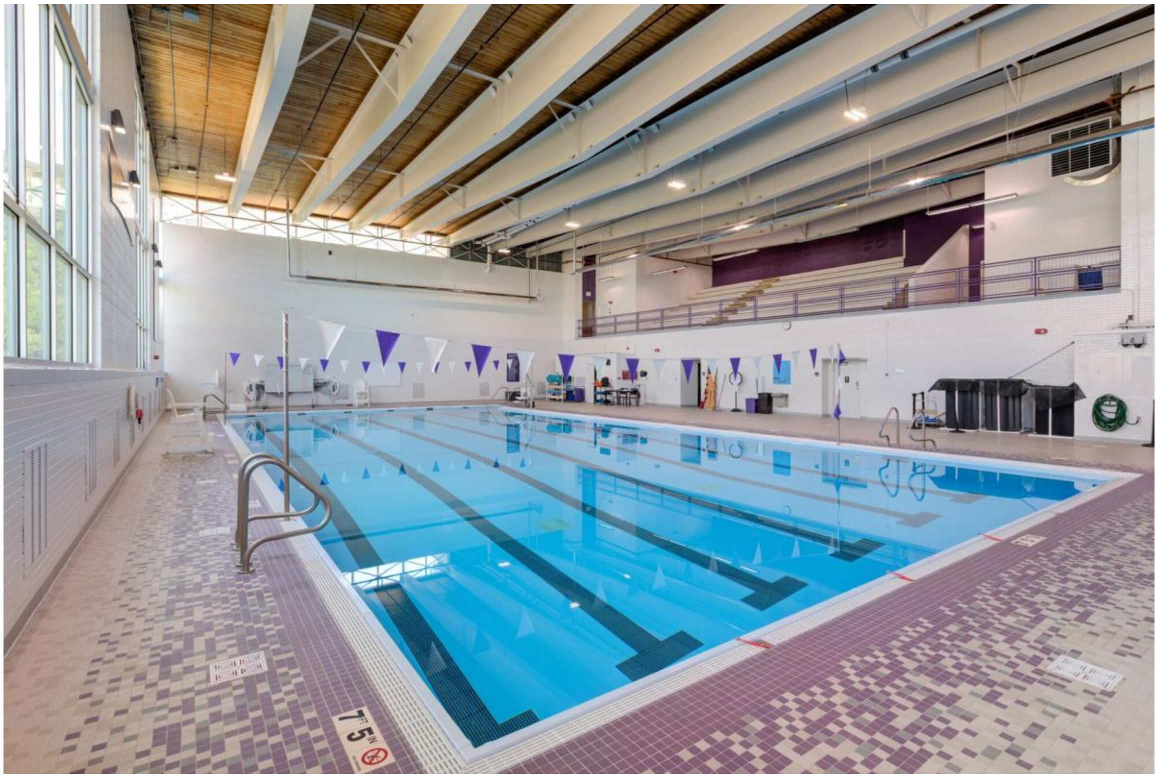


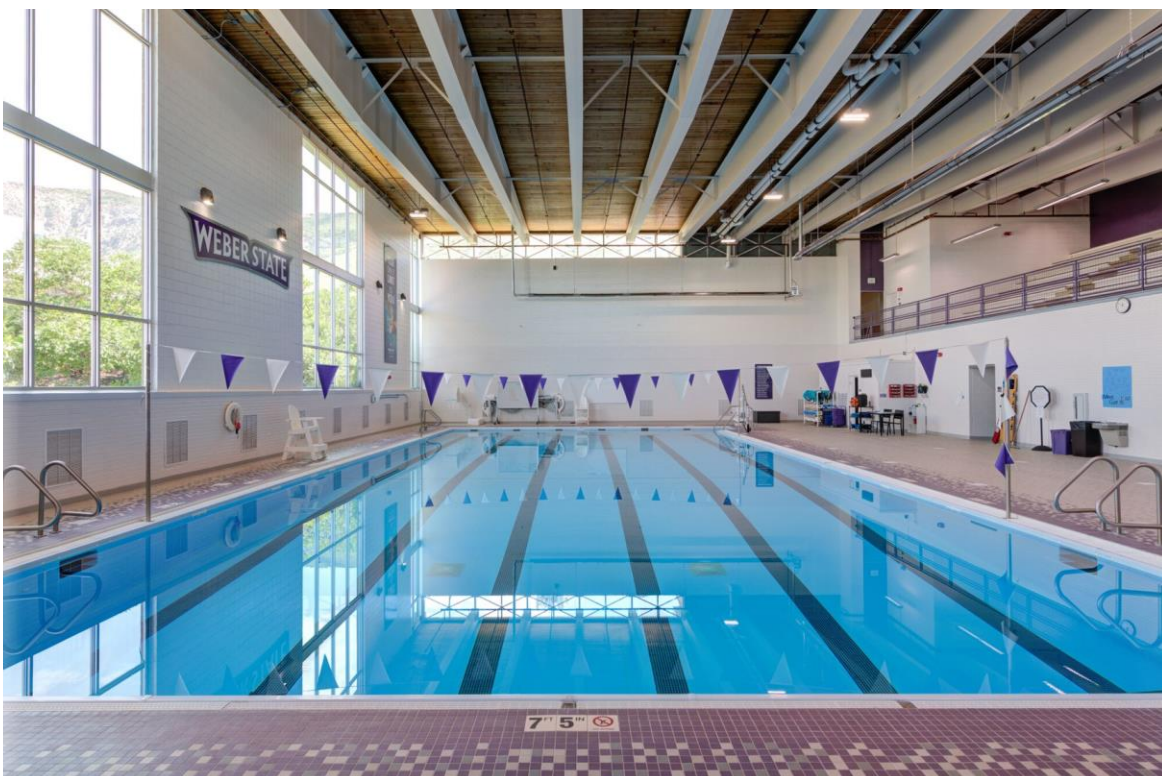
OPTION #4 -PVC CLAD STAINLESS STEEL SYSTEM EXAMPLE IMAGES

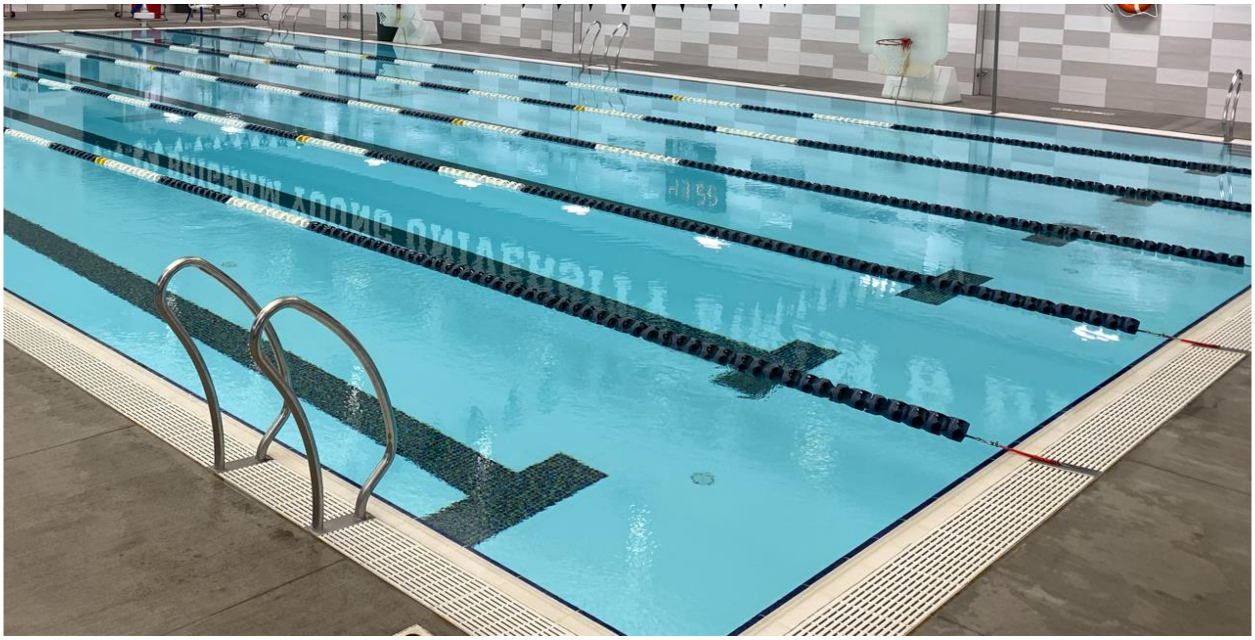
CONSTRUCTION IMAGES



FINISHED POOL IMAGES








4 FT 0 IN